NATIONALGEOGRAPHIC.COM/MAGAZINE | OCTOBER 2007

NATIONAL GEOGRAPHIC



GROWING FUEL

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POSTER: CHANGING CLIMATE

NATIONAL GEOGRAPHIC

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Changing Climate

THE SCIENTIFIC EVIDENCE IS CLEAR: Surface temperatures on Earth are warming at a pace that signals a decisive shift in the global climate, one expected to last for centuries. Previous epochal changes of climate, such as the Ice Age that ended 11,500 years ago, were set in motion by natural causes—variations in Earth's orbit that affect the amount of sunlight warming the planet. In those cases, the cycles of cooling and warming unfolded slowly, over the course of millennia. This episode is different.

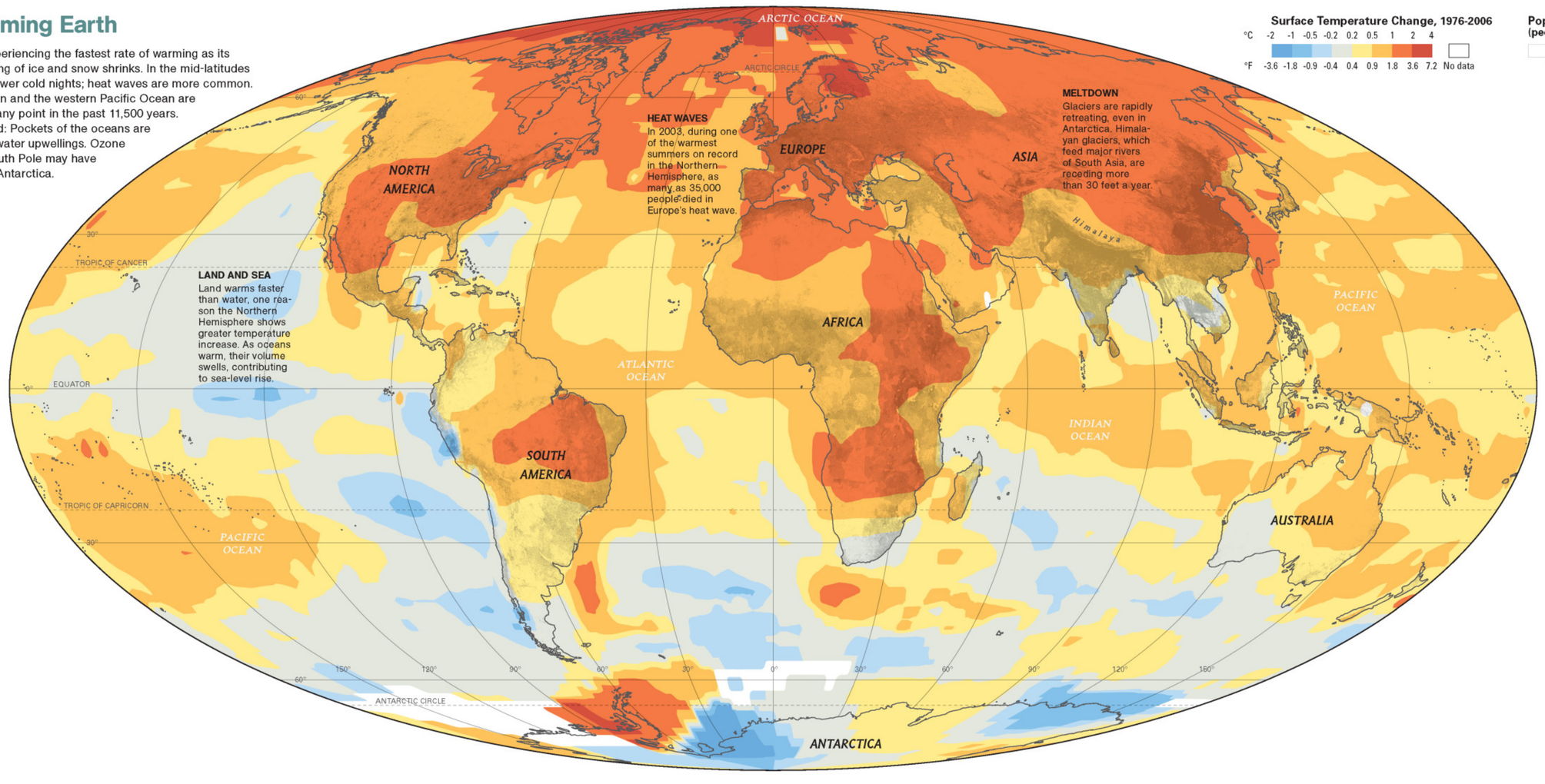
Climate is changing more rapidly than ever before. Human activity is the main cause. Burning of fossil fuels—oil, gas, coal—has flooded the atmosphere with heat-trapping carbon dioxide, triggering a 1°F (0.6°C) spike in average global temperature in the past century, largely in the past 30 years (top map). Already, impacts include altered precipitation patterns (bottom map), melting glaciers, intensifying storms, and a rise in sea level. Unless CO_2 emissions are slashed, the planet will likely heat up even faster, fundamentally changing the world we live in.

CLIMATE CONNECTIONS | NATIONAL GEOGRAPHIC | npr npr.org

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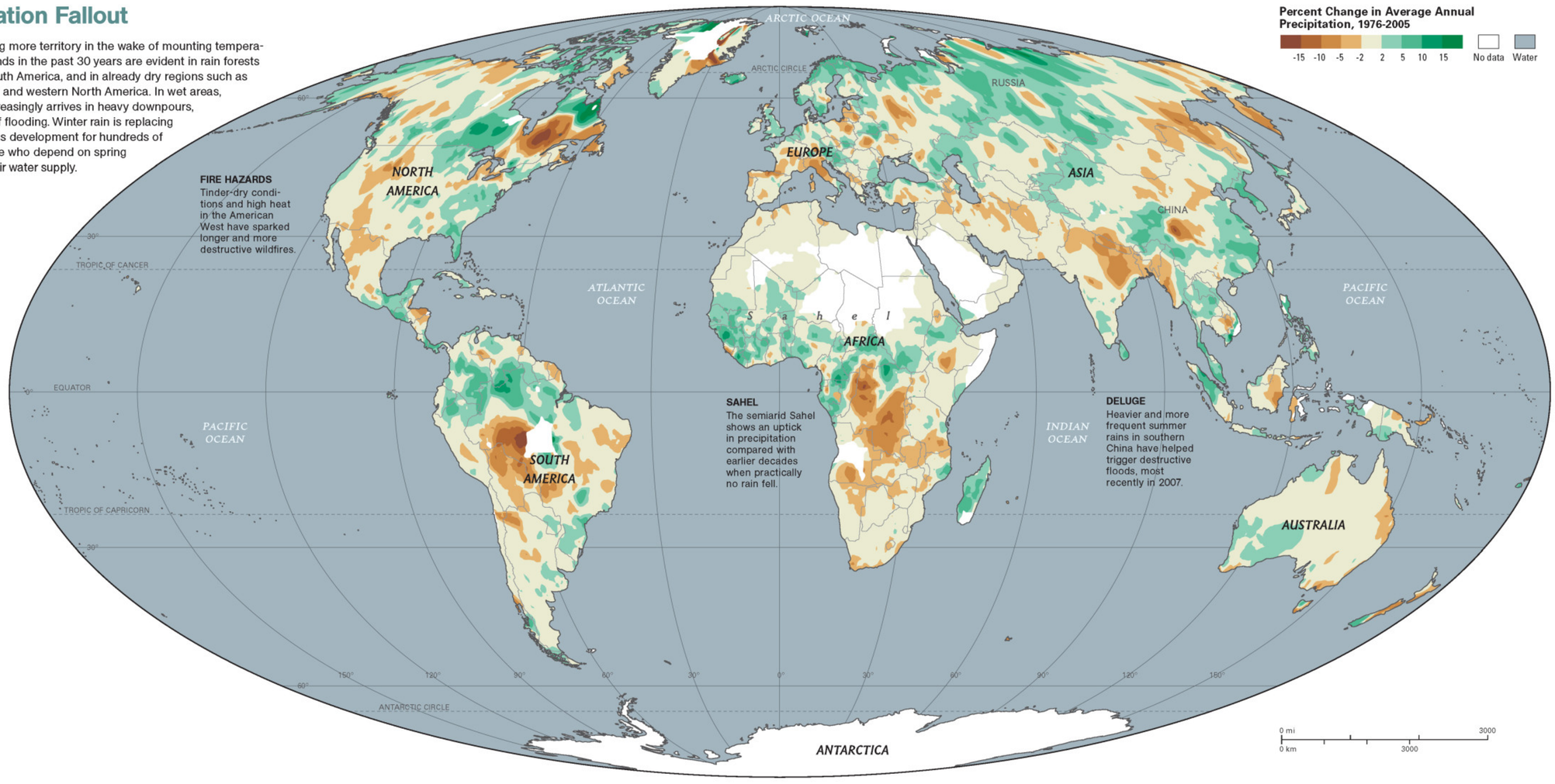
The Warming Earth

The Arctic is experiencing the fastest rate of warming as its reflective covering of ice and snow shrinks. In the mid-latitudes there are now fewer cold nights; heat waves are more common. The Indian Ocean and the western Pacific Ocean are warmer than at any point in the past 11,500 years. Against the trend: Pockets of the oceans are cooled by deepwater upwellings. Ozone loss over the South Pole may have cooled parts of Antarctica.



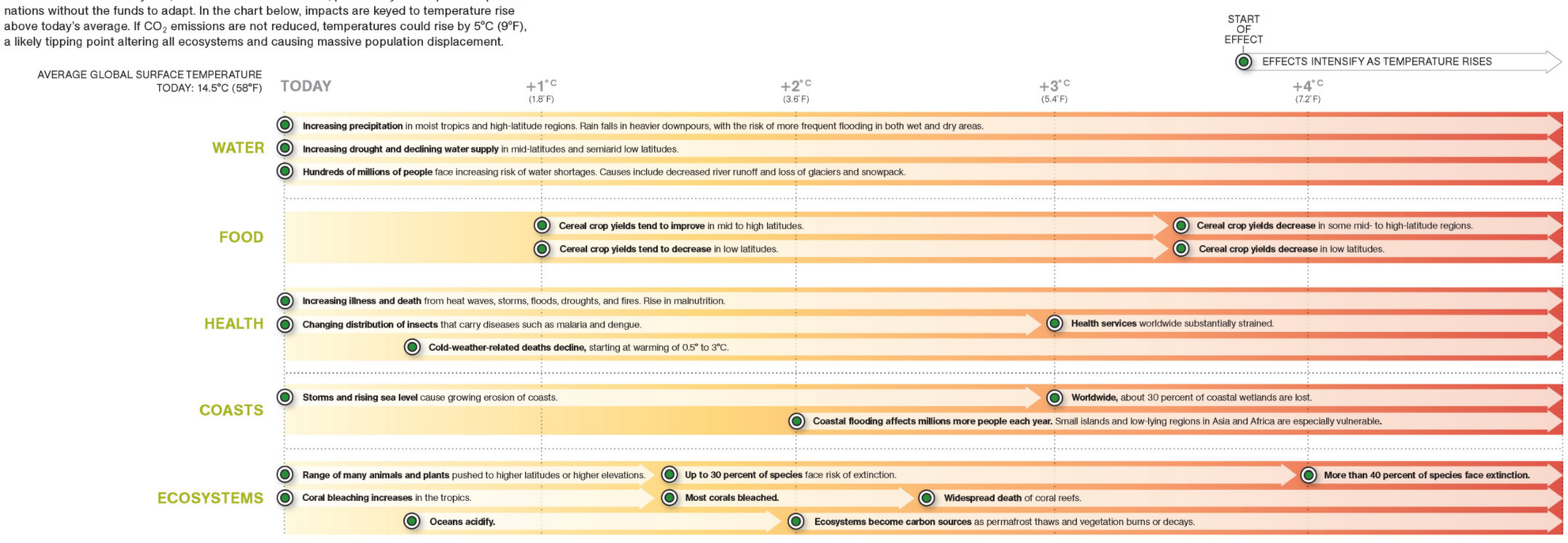
Precipitation Fallout

Drought is seizing more territory in the wake of mounting temperatures. Drying trends in the past 30 years are evident in rain forests of Africa and South America, and in already dry regions such as southern Europe and western North America. In wet areas, precipitation increasingly arrives in heavy downpours, raising the risk of flooding. Winter rain is replacing snow, an ominous development for hundreds of millions of people who depend on spring snowmelt for their water supply.



How the World Will Feel the Heat

Even a future with dramatic cuts in CO_2 emissions will see an additional temperature rise of 2°C (3.6°F) over the next century. Though a few regions such as Russia and northern Europe will benefit from warmer years, most of the world will suffer, particularly the tropics and poorer nations without the funds to adapt. In the chart below, impacts are keyed to temperature rise above today's average. If CO_2 emissions are not reduced, temperatures could rise by 5°C (9°F), a likely tipping point altering all ecosystems and causing massive population displacement.



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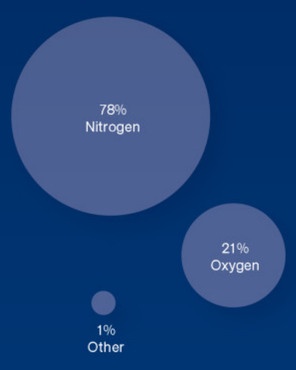
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Greenhouse Earth

Earth is hospitable to life because its atmosphere works like a greenhouse, retaining enough of the sun's heat to allow plants and animals to exist. This natural climate-control system depends on the trace presence of certain atmospheric gases—most importantly carbon dioxide—to trap the sun's radiation. But the system's stability has been jolted. The burning of carbon-laden fossil fuels has hiked atmospheric CO_2 to levels unprecedented during human history. Greenhouse Earth is growing warmer. How much warmer it gets depends on the human response.

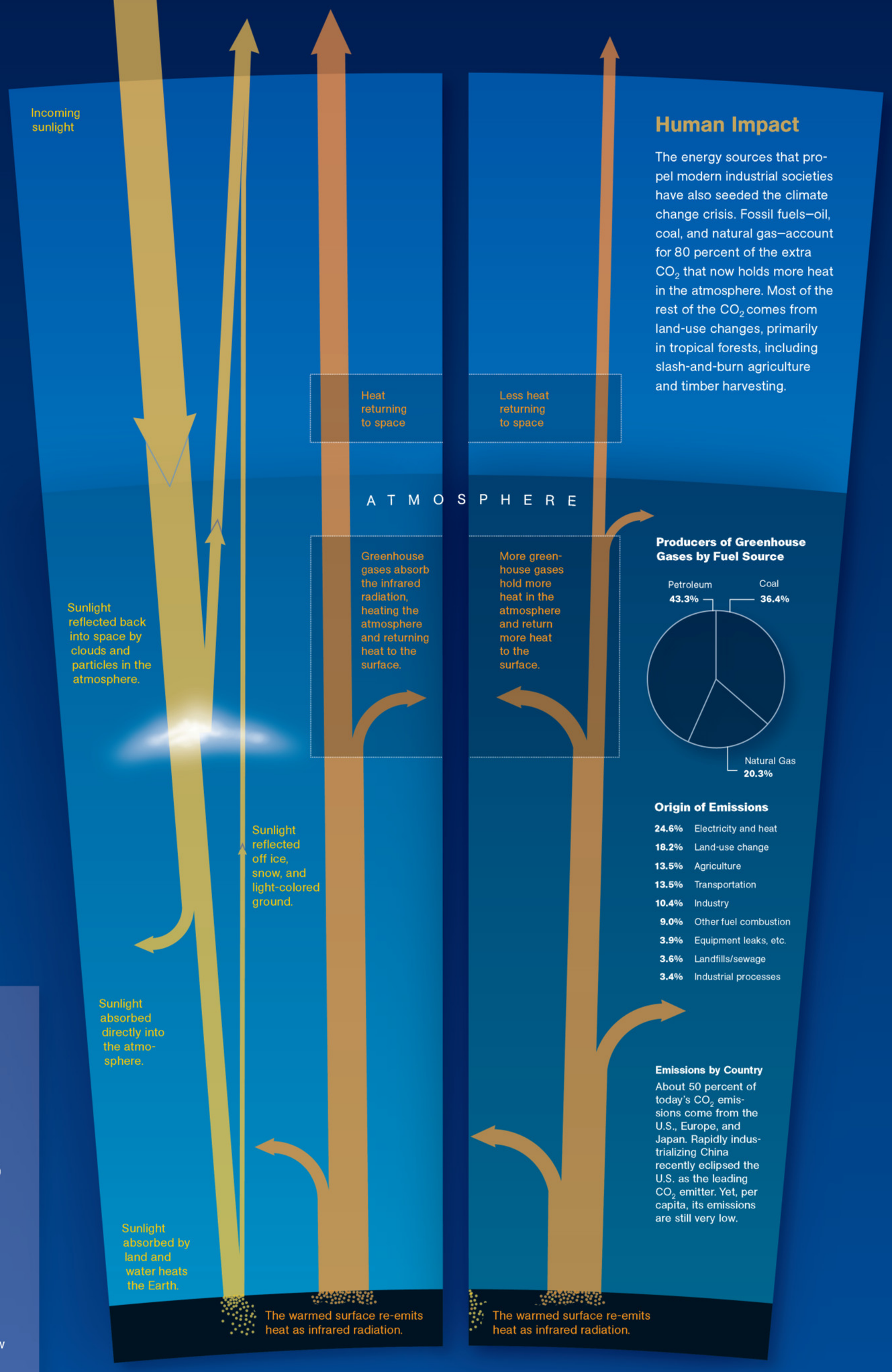
Natural Heating System

The global thermostat is set by the amount of solar energy retained by Earth's atmosphere (right). Land and water absorb incoming sunlight and transform it into heat, which is released back into the air as infrared radiation. Like the glass walls of a greenhouse, atmospheric gases, principally carbon dioxide, water vapor, and methane, trap most of the ascending heat and keep it in the lower atmosphere. Without this natural process, commonly called the greenhouse effect, Earth's average temperature would hover at a frigid 0°F (-18°C), instead of the present 58°F (14.5°C).



The Elements of Air

About 99 percent of Earth's atmosphere is nitrogen and oxygen, elements that absorb little heat. The crucial heat-retainers–CO_2, methane, and nitrous oxide–make up only a fraction of the remaining one percent. Human activities have increased the levels of all three. Water vapor and ozone are also important greenhouse gases; their amounts vary with local conditions.



Human Impact

The energy sources that propel modern industrial societies have also seeded the climate change crisis. Fossil fuels–oil, coal, and natural gas–account for 80 percent of the extra CO_2 that now holds more heat in the atmosphere. Most of the rest of the CO_2 comes from land-use changes, primarily in tropical forests, including slash-and-burn agriculture and timber harvesting.

Producers of Greenhouse Gases by Fuel Source

Origin of Emissions

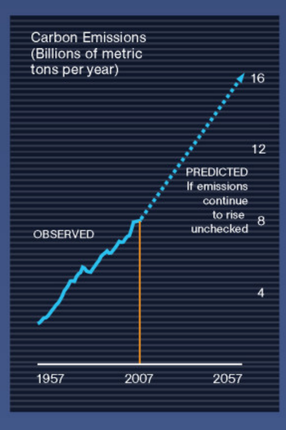
24.6%	Electricity and heat
18.2%	Land-use change
13.5%	Agriculture
13.5%	Transportation
10.4%	Industry
9.0%	Other fuel combustion
3.9%	Equipment leaks, etc.
3.6%	Landfills/sewage
3.4%	Industrial processes

Emissions by Country

About 50 percent of today's CO_2 emissions come from the U.S., Europe, and Japan. Rapidly industrializing China recently eclipsed the U.S. as the leading CO_2 emitter. Yet, per capita, its emissions are still very low.

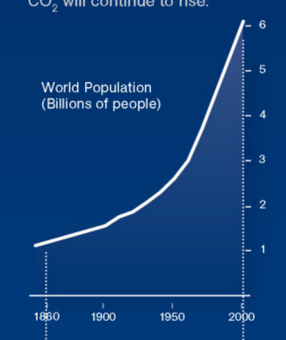
A Warmer Future

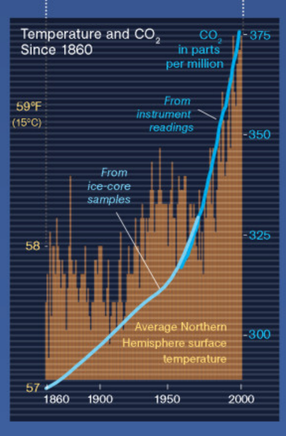
Carbon dioxide molecules stay in the atmosphere as long as 200 years, so even if emissions were eliminated today, the Earth would keep warming for centuries–though probably more slowly. If emissions were held at today's rate, CO_2 levels would still hit 525 parts per million, nearly double their pre-industrial level, by 2100, and the world would probably warm by several degrees. Business-as-usual could push CO_2 levels above 800 ppm, triggering temperature hikes of up to 9°F and likely overwhelming the ability of many species to adapt.



Population Demands

The doubling of world population since 1960 parallels the steepest climb of CO_2. Though population growth is now slowing, the rocketing economies of China and India, each with more than a billion people, ensure that CO_2 will continue to rise.



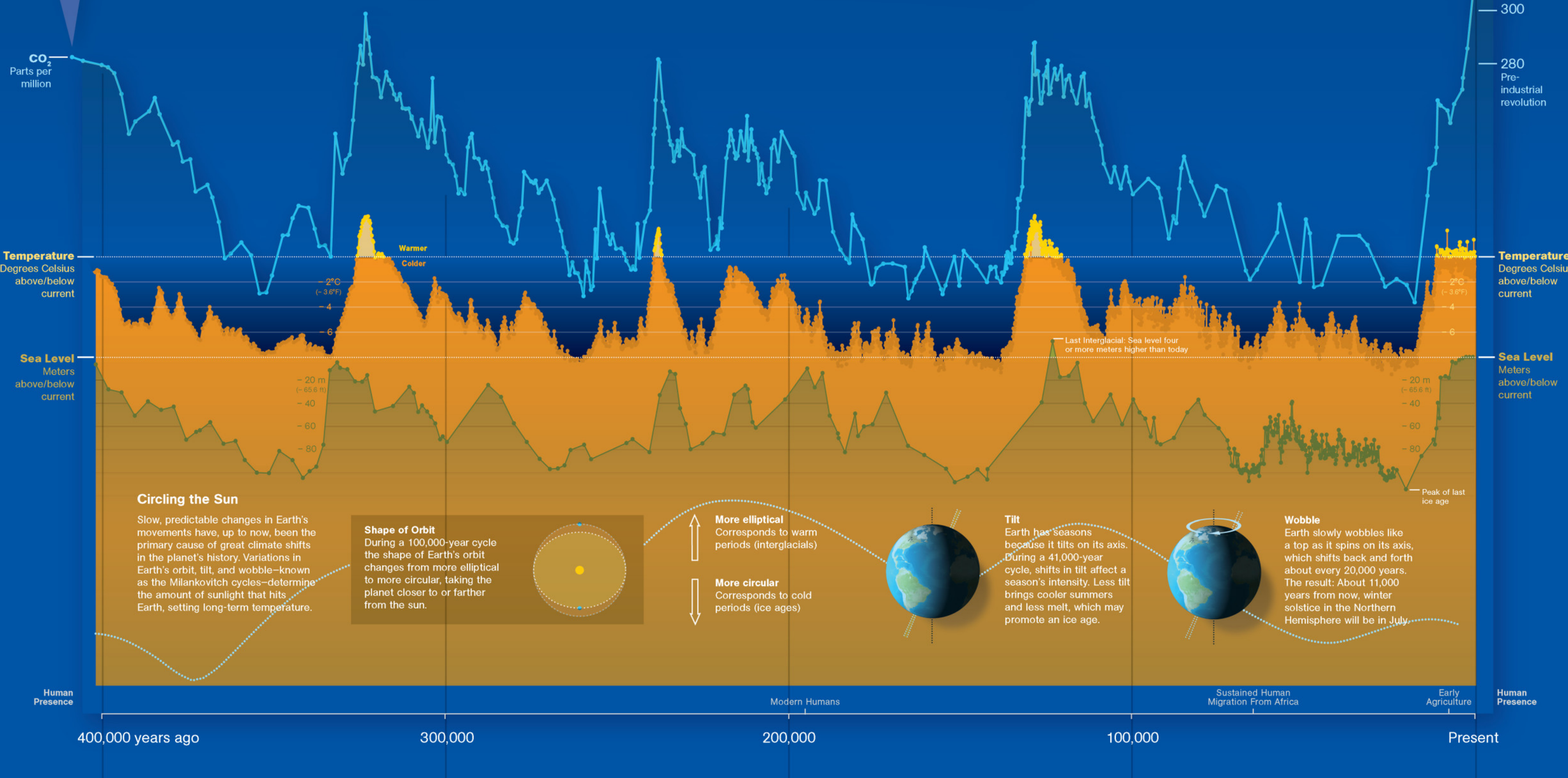


CO_2's Modern Imprint

The rise of CO_2 levels from 280 parts per million at the advent of the industrial revolution to 380 ppm today is the major factor driving a 1°F rise in the average global temperature during the past century. The pace of warming has accelerated: 11 of the 12 warmest years on record have occurred since 1995. Because the Earth's surface heats up more slowly than the atmosphere, temperatures have not yet caught up with the escalating concentrations of CO_2.

Ages of Ice and Heat

Carbon dioxide levels, as measured in Antarctic ice cores, have risen and fallen in step with **global temperatures** and **sea level** over the past 400,000 years (below). The record shows that long ice ages have gripped the planet, interrupted by shorter warming periods. The warm spells, or interglacials, occur every 100,000 years or so and last about 10,000 years, driven by changes in Earth's orbit and orientation. Historically, temperature rose first, then CO_2 increased, accelerating temperature rise. Sea levels followed in turn. What makes the current situation unpredictable is that never before has CO_2 climbed so fast and so high during an interglacial, far ahead of temperature. Now temperatures and sea levels are being drawn upward; how quickly they will continue to rise is not known.



Circling the Sun

Slow, predictable changes in Earth's movements have, up to now, been the primary cause of great climate shifts in the planet's history. Variations in Earth's orbit, tilt, and wobble–known as the Milankovitch cycles–determine the amount of sunlight that hits Earth, setting long-term temperature.

Shape of Orbit
During a 100,000-year cycle the shape of Earth's orbit changes from more elliptical to more circular, taking the planet closer to or farther from the sun.

More elliptical
Corresponds to warm periods (interglacials)

More circular
Corresponds to cold periods (ice ages)

Tilt
Earth has seasons because it tilts on its axis. During a 41,000-year cycle, shifts in tilt affect a season's intensity. Less tilt brings cooler summers and less melt, which may promote an ice age.

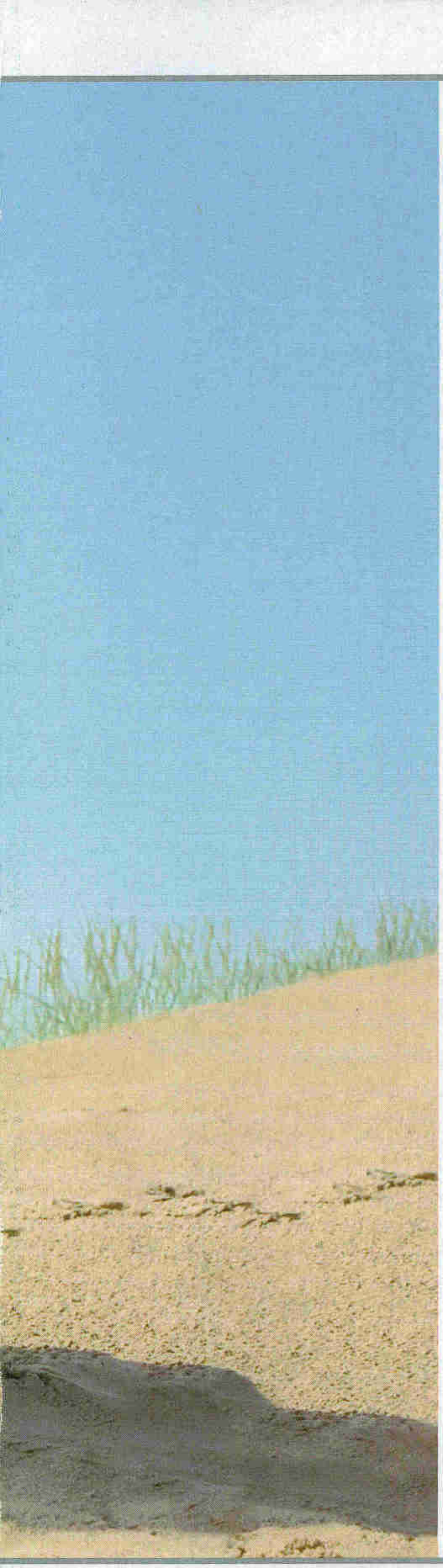
Wobble
Earth slowly wobbles like a top as it spins on its axis, which shifts back and forth about every 20,000 years. The result: About 11,000 years from now, winter solstice in the Northern Hemisphere will be in July.

Being anxious about the future.

Being excited about the future.



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LYNN JOHNSON

This infant long-tailed macaque is one of many mammals, birds, and reptiles sharing space—and possibly dangerous pathogens—in the animal markets of Jakarta, Indonesia. Story on page 78.

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The CO_2 from fossil fuels lingers in the atmosphere, so global warming can't be undone. But catastrophe can still be averted.
BY BILL McKIBBEN
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Producing fuel from corn and other crops could be good for the planet—if only the process didn't take a significant environmental toll. New breakthroughs could make a difference.
BY JOEL K. BOURNE, JR. PHOTOGRAPHS BY ROBERT CLARK

Latin America From the Sky 60
A condor's-eye view reveals a colorful mosaic of smoldering volcanoes, gleaming tin and tile roofs, and fanciful flamingos.
INTRODUCTION BY MARIE ARANA PHOTOGRAPHS BY ROBERT B. HAAS

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When zoonotic diseases pass from animals to humans, pandemics can result. Scientists are tracking lethal new viruses.
BY DAVID QUAMMEN PHOTOGRAPHS BY LYNN JOHNSON

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Sputnik left Earth a half century ago this month. Now proponents hope to revive the romance of human space exploration.
BY GUY GUGLIOTTA

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Modern pirates have long plagued Southeast Asia's Strait of Malacca, robbing sailors, kidnapping crews, and stealing entire ships.
BY PETER GWIN PHOTOGRAPHS BY JOHN STANMEYER

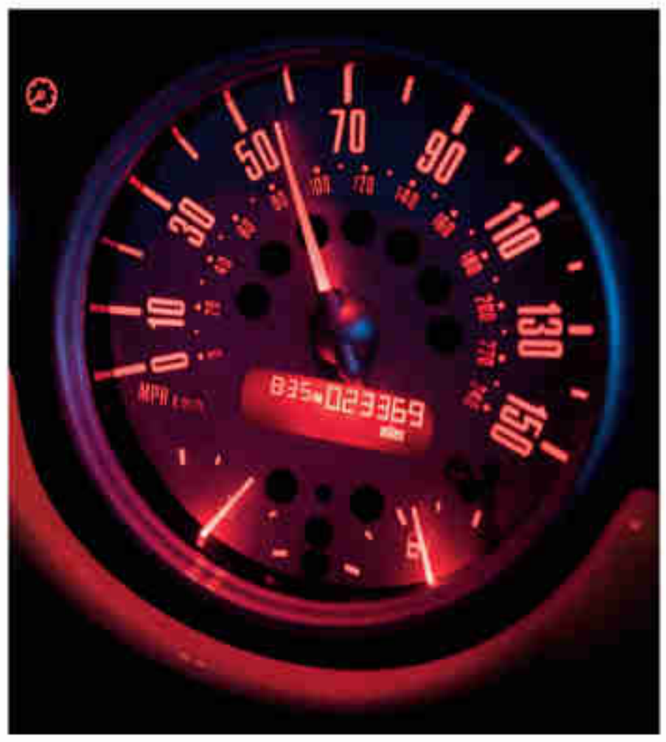
COVER The farmer who grew this ear of yellow feed corn hopes he'll get a higher price from an ethanol factory opening nearby.
PHOTO BY ROBERT CLARK

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A New Species



Autobahn Speed Limits



Jodhpur, India

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Jodhpur, India
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Disappearing Tongues
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Photo Contest
Shutterbugs, get busy. NATIONAL GEOGRAPHIC's new photo contest is calling for images of people, animals, and landscapes, as well as photo essays. The deadline is October 31. Learn more at *ngphotocontest.com.*

Sharper Visions
The full set of Visions of Earth photographs is now online, along with a map that pinpoints the 2007 locations, at *ngm.com/visionsofearth.*

Keeping Up With the Climate
The latest reports from *Climate Connections,* an ongoing collaboration between National Geographic and NPR, are posted at *ngm.com/climateconnections* and *npr.org/climateconnections.*

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EDITOR'S NOTE

My family's journey to the land of biofuels began when my wife, Elizabeth, and two of her friends, Rosa and Ellen, bought subcompact diesel automobiles. They researched hybrids, but because we live in a rural area, with no stoplights, sparse traffic, and vast distances, diesel appeared to be a better choice. Given their desire to consume less energy, the 45-mile-a-gallon vehicles seemed perfect. They were further swayed by the recent introduction of ultra-low sulfur diesel that significantly cuts emissions, as well as the cars' ability to run on biodiesel. As its name implies, biodiesel is fuel processed from biological sources instead of petroleum. It is renewable, nontoxic, and typically reduces greenhouse gas emissions by more than 60 percent over conventional diesel.



Algae cultures grow in a biodiesel lab.

Now alternative fuels are a topic of conversation in my family. My children are intrigued with the thought of riding in a car powered by used cooking oil from the local fast-food restaurant. We've pointed out that biodiesel comes from sources like soybeans, but the concept of a soybean-powered car bored them. We recaptured their interest, however, when we mentioned the promise of algae as a biofuel. My ten-year-old son, Tim, thought the cool quotient of algae surpassed that of cooking oil. But my teenage daughters, Noel and Louise, preferred the idea of filling the tank with cooking oil in the hope that the exhaust would smell like french fries.

Is biodiesel the answer to the energy and environmental challenges we face? Not by itself. But it is a step in the right direction when combined with other innovative solutions. Besides, filling up your car with biodiesel may provoke some interesting family conversations.

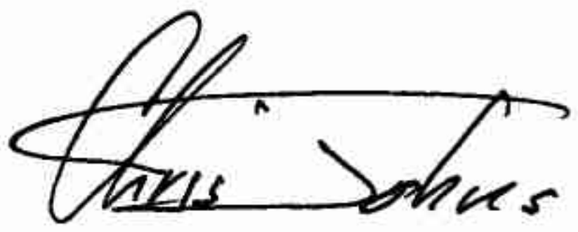


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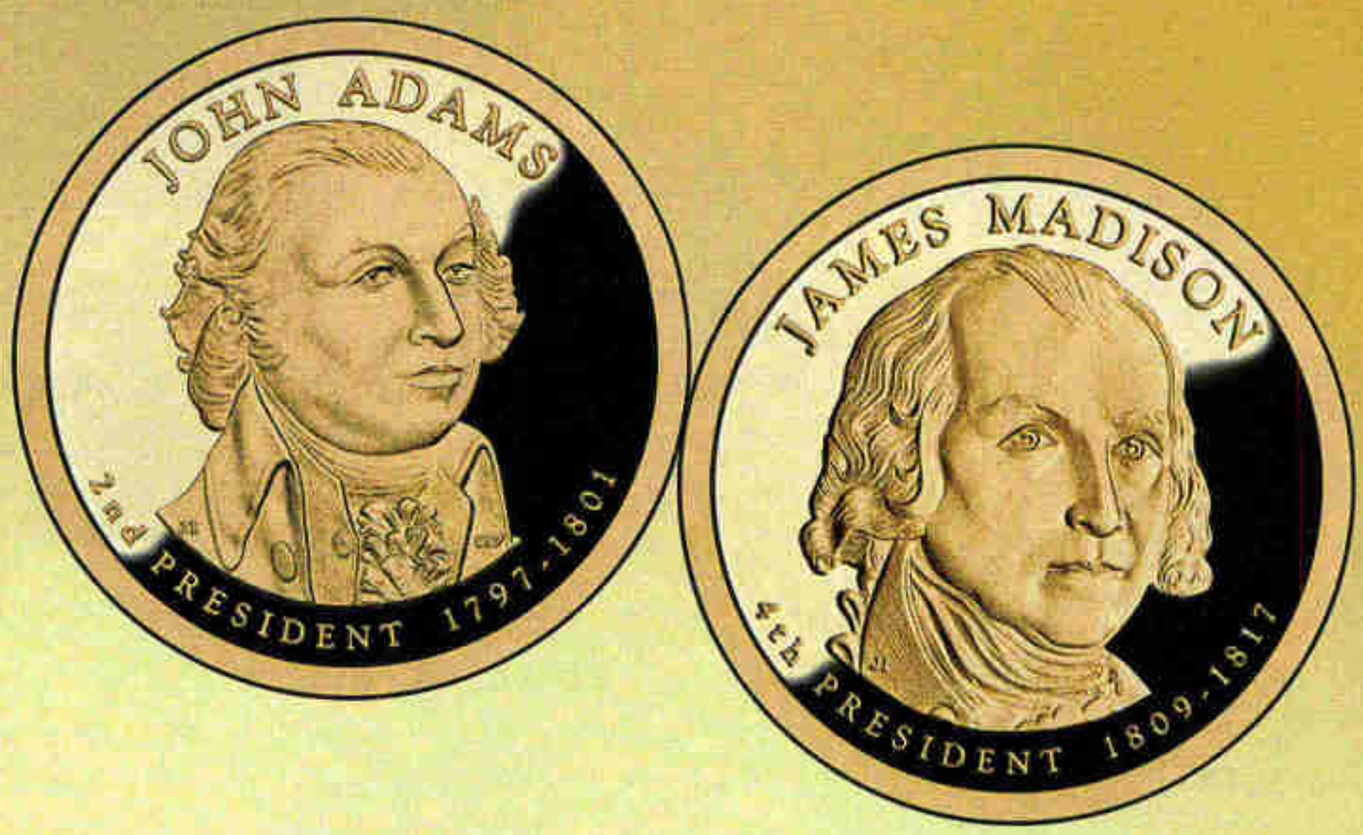
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LETTERS



June 2007 *The stories on melting ice moved many readers to write. Two California opinions: John Jaeger of Irvine isn't worried about polar bears, noting, "One single species is trivial." But Fresno's Stephanie Kakes says, "Seeing those beautiful animals jeopardized by my own choices inspired me to put aside my car keys and literally run my errands."*

Comment on October stories at **ngm.com**.

The Big Thaw

Global climate is changing as it always has; species will go extinct as they always have; other species will prosper. Yes, we may be influencing change, but we have not created change. While I think it is important to determine and monitor what changes we may be influencing, please remind your readers that change is natural and Earth will continue to change no matter what we may or may not do. We must accept this and figure out how to best adapt—not control it. As Charles Darwin said, "It is not the strongest of species that survives, nor the most intelligent, but the one most adaptable to change."

RANDI S. MARTINSEN
Laramie, Wyoming

Were he alive today, John Muir, naturalist and conservationist, would certainly decry the melting of glaciers and other frozen places around the globe. To continue to ignore the obvious warning signs of global warming is to hasten not only our own demise, but all life as we now know it. Wake up, people! Mother Earth is knocking loudly on our door!

MONICA ALEXANDER
East Otis, Massachusetts

Global warming is as dynamic as many other earthly processes. To deny that the Earth is warming is ignorance; to believe it's man-made is foolish. We must remember that we are still coming out of an ice age, a mere 11,500 years past—a gnat on an elephant's hindquarter given the billions of years the Earth



has evolved. I recently had the opportunity to visit the Hubbard Glacier in Alaska. The park ranger stated that it is growing. Why is this, and how does its growth rate compare with others receding?

TIM CARTER
Stoughton, Wisconsin

Most of the world's glaciers are thinning and receding. Few are advancing. Hubbard's atypical growth is due to the heavy snowfall it receives, a large percentage of which occurs at very high elevations. This overcompensates for the melting and calving that occurs at its end.

It seems odd that those who deny that global warming is caused by mankind claim that supporters of the concept have ulterior motives, when it is clearly evident that the naysayers have the obvious ulterior motive: to carry on comfortable and profit-motivated lifestyles. Naysayers often claim that the warming of the Earth is a natural cycle and that the melting is just part of this cycle. However, it seems evident that it is more than mere coincidence that these glaciers and ice sheets have been around since long before man swung down from trees. Yet these natural features of such incredible scale are melting and disappearing before our very eyes.

CHRISTIAN GLENN
Woodbridge, Virginia

Your article warns us about the dangers of global warming caused by "cars and industry." It then tells us that the scientists who study the big thaw do so by snowmobile, truck, rocket-launched satellite, helicopter, and Chilean Navy airplane. If the scientists themselves can't stop spewing petrochemical pollution—directly into the heart of these endangered environments, no less—why do they think anybody else should or will?

JOHN RUCH
Boston, Massachusetts

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LETTERS

Unbelievable. Of course I am not talking about what was written in "The Big Thaw" but rather reacting to the persisting deniers and their justifications as to why human-induced climate change is an alarmist's hoax. I am sure there are some harmless folks out there who still believe the Earth is flat. But apathy and disbelief about climate change are far from harmless; they affect governmental policy and our ability to take action. While it is difficult to predict precisely how global climate change will affect us, the real challenge today is to mobilize the populace: How am I affecting climate change? What sacrifices am I able to make? And what should my government do about it?

MICHAEL ALBERT
Racine, Wisconsin

Life at the Edge

While I have never been to the Arctic, Paul Nicklen's photographs in "Life at the Edge" instantly transported me to this ice paradise. It was apparent to me that the Arctic is not a frigid, sleepy land far away but one teeming with the life and vitality of animals that have a story to tell. Perhaps these images will show others that the world is worth saving, even in places we have never been.

JOHN D. TRYBUS
Washington, D.C.

Corrections, Clarifications

June 2007:
Visions of Earth The ruins in the first picture predate the Soviet era.
A Passion for Order The photo on page 87 shows *Musa ornata,* a banana plant from Bangladesh.
Instant Cities The correct spelling of the city on page 117 is Youzhu.

China's Instant Cities

Is this what Europe experienced at the time of the industrial revolution? If the Chinese are abandoning and building over their agricultural lands, how will they feed themselves? I cannot begin to imagine what environmental impact all this moving of mountains will have, and what about pollution?

MARY LYNN GULLETTE
Blue Bell, Pennsylvania

I have been working with various Chinese companies that produce U.S. consumer goods for more than ten years now. Peter Hessler's article and Mark Leong's photographs hit the mark in conveying a sense of what is happening in China today. Most Americans have no idea—and maybe most really do not want to know—what is going on there. I know of no American who would trade places with the average Chinese factory worker. On the other hand, most Americans do not question where their goods come from so long as the price is low. The Chinese are energetic, driven, and hungry to improve their lives. They want their families to be happy, safe, and filled with hope that the future will be better. But their path is leading them straight into a dangerous future, in my opinion. It might be economic boom time now, but lying beneath the surface, a bomb ticks away quietly. And since we all live on the same planet, we all share in the responsibility to quickly and compassionately deal with this danger.

JIM PENNY
Arcata, California

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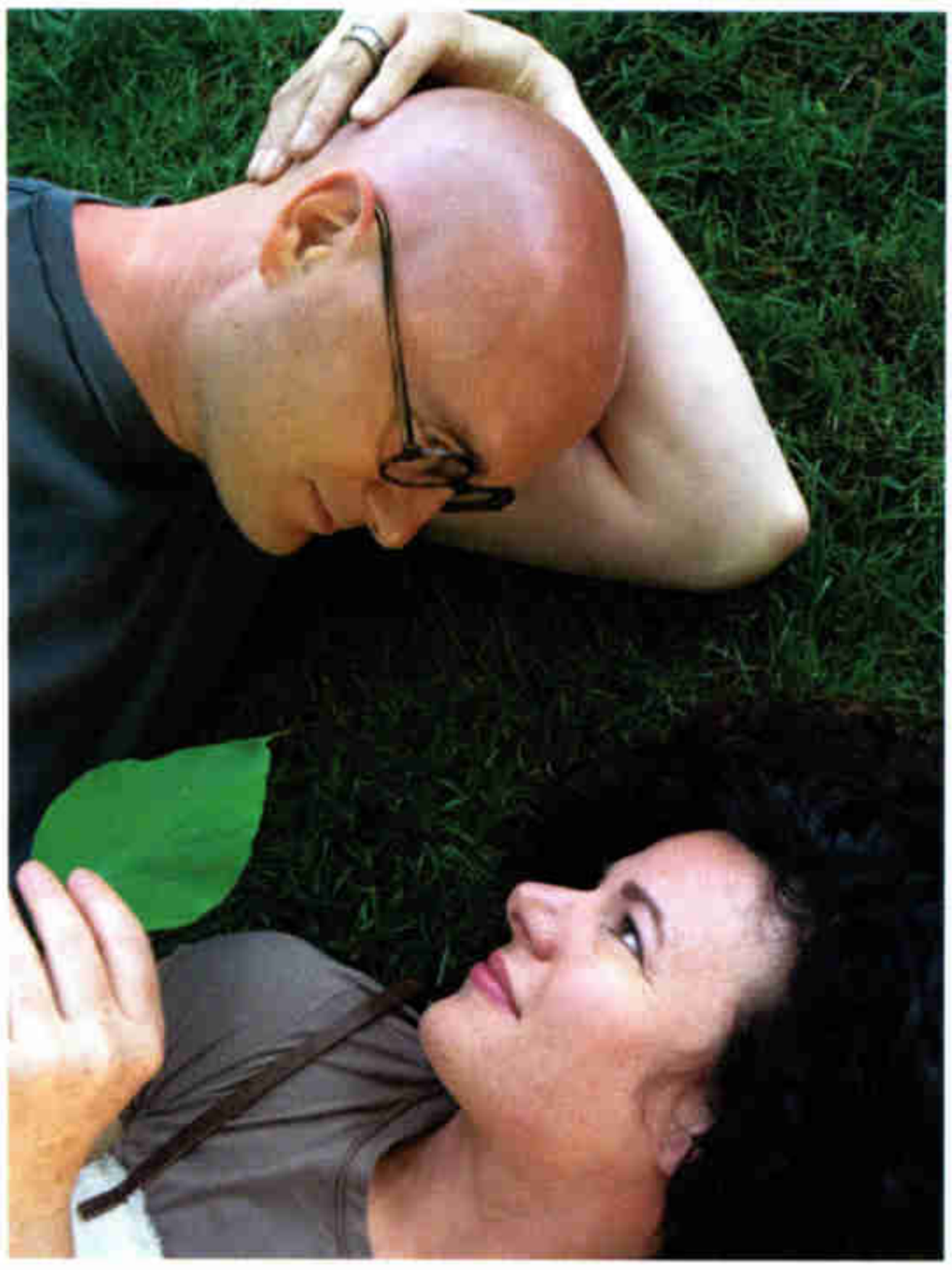


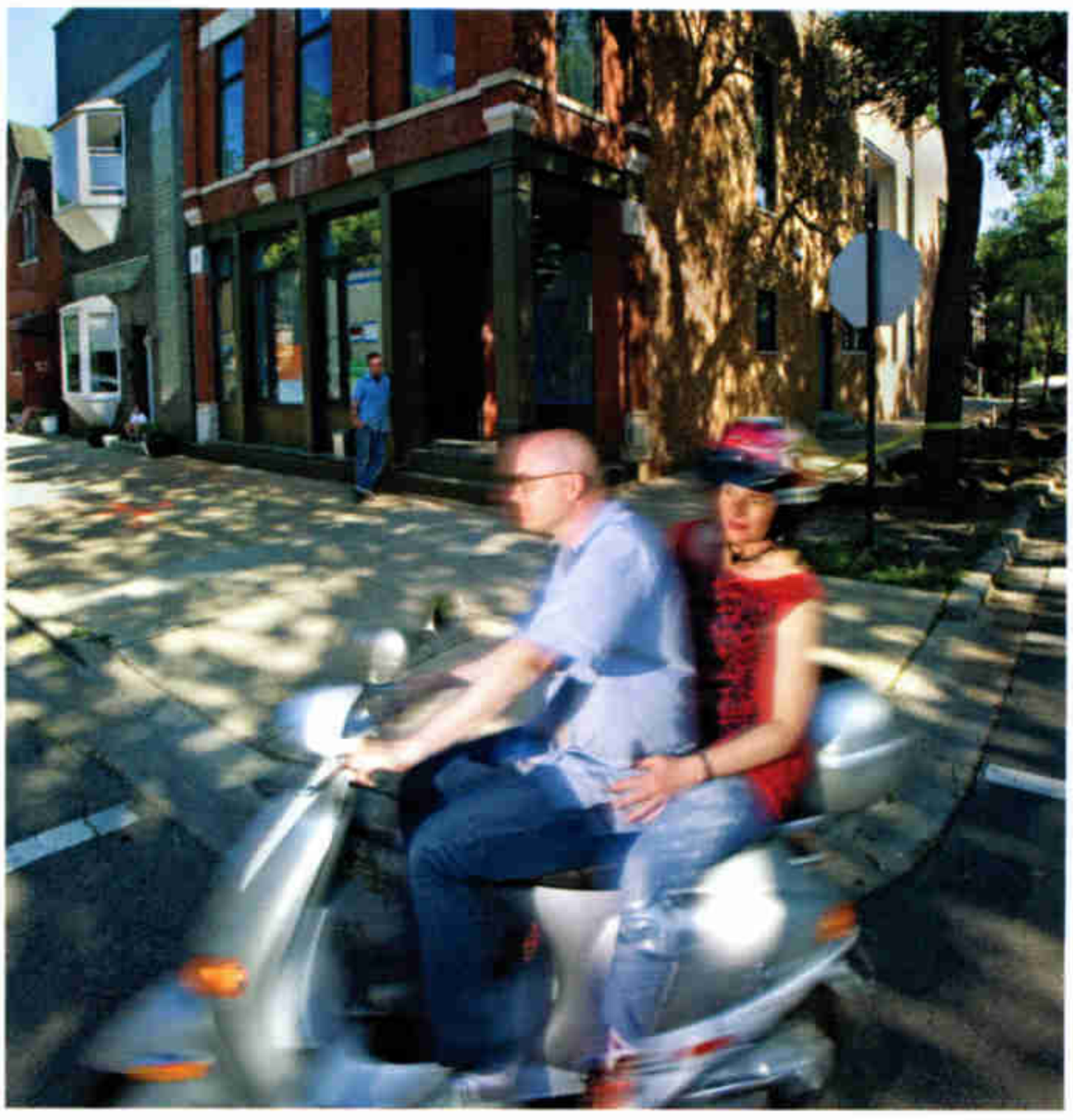
A Green Groove

By dreaming big and planning smart, one Chicago couple has turned their personal passions into a rewarding life that will continue to give back for years to come.

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Dream On

➤ Joining the mainstream never really interested Frank and Lisa Mauceri. Both proud dreamers even before they met at a Los Lobos concert back in college 20 years ago, the Mauceris use outside-the-box thinking as a creative technique to nurture their eco-friendly life. By merging their record company ambitions and their love of the environment they have created an environmentally inspiring live/work space they hope will ignite the imaginations of their Chicago community and colleagues in the recording industry. Their newly renovated building, a former old corner store and bar located in Chicago's artistic Bucktown neighborhood, is the United States' first and only residence that is LEED certified—a green-building rating system designed by the U.S. Green Building Council—generating its own electricity through the use of solar panels and wind turbines, and using geothermal heating and cooling.

Although the couple was on a traditional corporate track—Frank worked as an attorney and Lisa worked in finance—they dreamed of ditching the 60-hour work weeks that were feeling increasingly pointless. As devoted rock-and-rollers, they wanted to dive headfirst into their musical passions. After stints in Cleveland and Reno, the pair decided to reinvent their life in Chicago. "Chicago stood out to us," says Frank. "The Windy City has one of the strongest green initiatives in the country and is striving to be the greenest metropolitan area in America."

With the help of a green-savvy architect, they created a building plan that includes two wind turbines, 30 solar electric panels, geothermal heating and cooling, and a 1,900-square-foot green roof that serves as the home's yard. "The wind turbines in combination with the solar panels should create at least 40 percent of all the electricity we need. Under ideal conditions it will produce 100 percent," says Frank. And there's even a chance that the Mauceris' system might produce more energy than is needed for their home, in which case the excess electricity is distributed back to the city's energy grid and they receive a credit on their electric bill.

As with any construction project, there were stumbling blocks. Despite Chicago's green reputation, the city's residential height restrictions prohibited building the wind turbines. But by working with the city, the couple helped Chicago create new ordinances which now exempt wind turbines from the height restrictions.

"Our neighbors are really fascinated by what's happening on the roof," says Lisa. "We had to get the okay from them to do the wind turbines, and they were like, 'Yeah, go for it.' They had no problems at all." One of the couple's favorite design features is the use of crushed record bits in the flooring material, which they helped to create. Frank smashed the records with a hammer and then Lisa ground the bits with a blender. "It's a really personal way to recycle and it really screams 'us,'" says Lisa.

"I felt, and still feel, that the more people I tell about this way of living, the bigger positive impact I'll have, and the less negative impact we will all have on the environment," adds Frank.

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Photography made possible by National Geographic Image Collection; Dawn Kish, photographer.

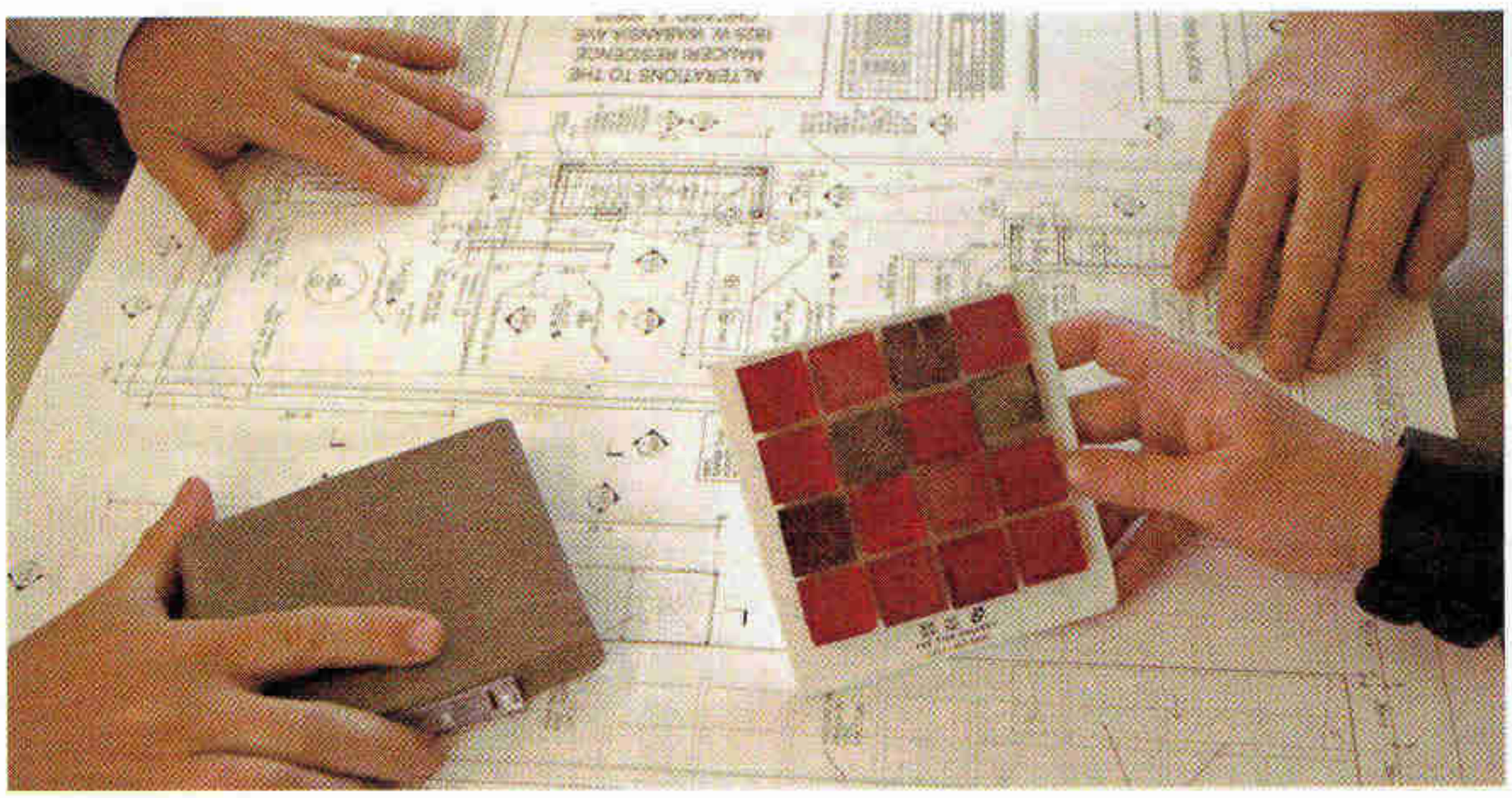
Plan for the Future

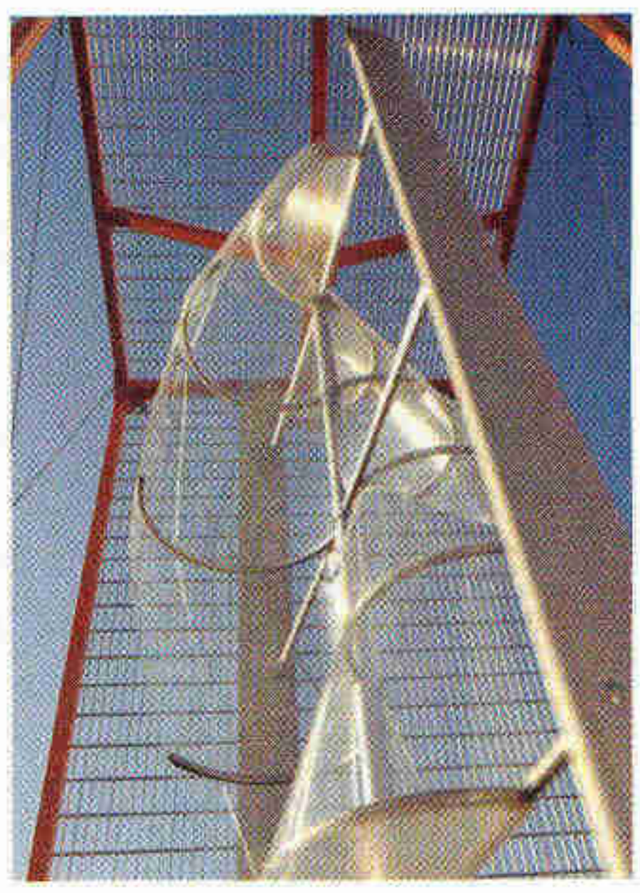
The 5,600-square-foot structure offers plenty of room for their record company, Smog Veil Records. Frustrated by the amount of waste in the music business, the Mauceris are running Smog Veil under strict green guidelines. One first step is starting to release music in MP3 format instead of as CDs.

"We're eliminating the use of jewel cases and using cardboard packaging instead, replacing paper press kits with PDFs, offering downloadable digital booklets from our website instead of CD inserts, and taking the message of greening the music industry to others in the hopes that they will implement those practices within their business," says Frank. In addition to these moves, the Mauceris say they practice the everyday acts that anyone can do: being careful about the amount of energy they use in the office, recycling paper, and composting. "We'd also like to replace our inefficient delivery truck with a waste-vegetable-oil, biodiesel, or electric model," says Lisa.

Measuring their efforts is an important part of the Mauceris' plan. "It's important for us to be able to track what our efforts do," he says. "We're taking special care to measure how much paper we've used in the past in our business and how much we'll be using once our green agenda is fully implemented.

"In the music industry, the one thing that's going to make a difference is showing that the implementation of green practices within your business reduces your overhead and increases your net profits."





Track Progress

Like so many people who crave an epic life they can be proud of, the Mauceris kept their eye on the future and harnessed their dreams. "Now I feel like I can go to sleep at night under this very green roof and feel good about myself, my house, and the way we choose to live," says Lisa. "If I can make a difference, even if it's a very small personal difference, I'm glad to do it. It's our green dream come true."

When asked if she and Frank view themselves as dreamers, Lisa responds with an affirmative yes: "Absolutely. It's always important to be optimistic about life and what you're doing so you're not stuck in a bubble. I think you see limitless possibilities when you're dreaming, and then it gives you excitement and the vision to keep going forward."



Go online to see the finished home and follow the couple's story at ***nationalgeographic.com/LifeDreams***

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LETTERS

A Passion for Order

The tiny portrait of Carl Linnaeus in his Lapp costume on page 78, almost lost in the stunning glow of the *Malope trifida* on the next page, is telling. In his hand, Linnaeus holds the *Linnaea borealis,* or twinflower. This is the flower *(landskapblomma)* of the Swedish province of Småland, where Linnaeus—and my father—were born. Local lore says that Linnaeus was so fond of the fragrant pink twin-belled flower that he wore it in his lapel.

CARLA PETERSON EYLERS
Harwinton, Connecticut

I happen to be a fuchsia nut and have fuchsia stuff all over my house, even though I can't grow them here in Illinois. Was the picture on page 72 printed upside down? I know that some fuchsias grow on small trees in parts of the country, but most of what I have seen are in hanging baskets.

SANDI BENNETT
Shiloh, Illinois

Helene Schmitz photographed the reproductive structures of the plants in order to highlight Linnaeus's classification system. She showed these structures by occasionally shooting plants such as the fuchsia from an angle that wouldn't normally be seen in a garden.

Arlington Cemetery

The beautiful tribute to the Arlington National Cemetery touched me deeply, although I missed any mention of the many women who were and are veterans. I am one, an Army nurse, who served in World War II, in the Philippines, and entered Japan in October 1945. I am very proud of my campaign medals and Bronze Star. My dream has always been to be buried at Arlington. That desire has dimmed through the years, realizing the costs and logistics involved. Attention must be paid to the women who have served bravely and with honor in the wars.

DELPHINE DONNELLY
Gold Canyon, Arizona

As there is no place for war protest at Arlington, I can't help wishing that the growing lack of space there would make an end to war an inevitable consequence.

Being an antiwar advocate, I expected only to skim Rick Atkinson's "The Nation's Cemetery." However, Atkinson does objective justice to the need for Arlington National Cemetery as a place of mourning, remembrance, and symbolic ritual. Nevertheless, as there is no place for war protest at Arlington, I can't help wishing that the growing lack of space there would make an end to war an inevitable consequence. Thank you for publishing yet another article that made me think about things I never thought I would.

AMY REFF
Berkeley, California

On page 136, the author mentions the "playing of 'Taps.'" "Taps" is "sounded," not "played." My father, who retired from a career in the Army, always insisted upon the correct verb. His funeral was celebrated with full military honors on a stormy day at Fort Sam Houston in San Antonio, Texas. When the soldier explained the significance of the "playing" of "Taps," we were all shocked by an enormous clap of thunder. My guess is that Dad asked God to make the correction.

TERESA DENDY
Phoenix, Arizona

We'd just returned from Washington, D.C., with my daughter's eighth grade classmates when I opened the article. Arlington is hallowed ground, and our group honored the feeling by taking in the tour without a lot of typical teenage talking.

PEGGY TEGHTMEYER
Scottsbluff, Nebraska

Family of Man: Brides

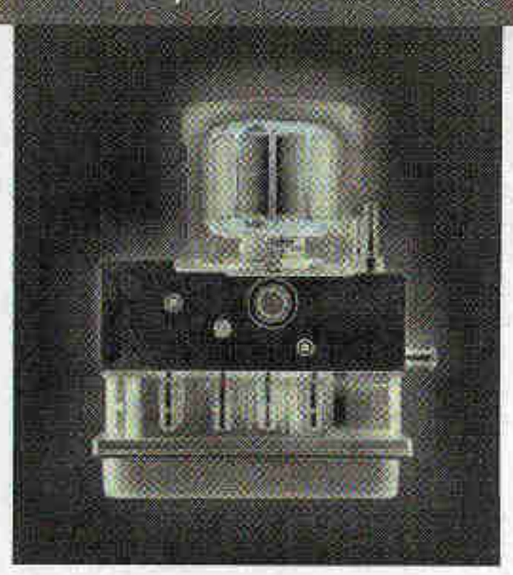
If you want to help lift the veil that covers many worldwide abusive practices against women and hides them behind more euphemistic words, you would not call "circumcision ritual" what could be defined as female genital mutilation or, in its worst form, infibulation. This cruel practice has drawn criticism from the international community and from many women who have undergone it. Unfortunately, the practice remains deeply ingrained and valued by the Maasai people, many of whom defend it as necessary because Maasai men typically reject women who have not undergone it.

CARMEN PEREZ-ILLADE
Oviedo, Florida

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LETTERS

Geography: Senior Highs

One conclusion: Older people are remaining in urban, ethnic areas while their children and children's children are migrating to the surrounding rural areas we now know as the suburbs.

BILL SHERLOCK
Boyne City, Michigan

Photo Journal: Bradford Washburn

I often wonder what possesses people to write to NATIONAL GEOGRAPHIC just to make a complaint or comment on what appears to me to be a minor mistake. I am still no closer to understanding the compulsion, but here I am writing in. My question is in regard to the photo on page 12 with the caption ". . . moonrise over the Grandes Jorasses." Since the lit side of the moon indicates the sun is somewhere off to the right side of the photograph, and the track of the moon across the sky would be similar to that of the sun—either preceding or following the sun—wouldn't it be correct to assume that the moon is more or less moving parallel to the horizon, and so should not be labeled as a moonrise?

DAVID ELSON
Brush Prairie, Washington

The original caption information accompanying Bradford Washburn's photograph describes the scene as a moonrise. Geoff Chester of the U.S. Naval Observatory notes, "Your reader scores technical points. Semantically, I'd still say this qualifies as a moonrise. It's hard to see the moon's phase, but it appears to be a waxing gibbous, probably taken in the late spring, when it would be rising in the southeast. It can be considered as 'rising' until it transits the meridian—the imaginary line passing from north to south through the zenith. While it may appear to be moving parallel to the horizon, its altitude will continue to increase until transit. Then it begins to decrease."

THE PLACE WHERE YOU DREAM ISN'T ALWAYS
THE PLACE WHERE YOU SLEEP.



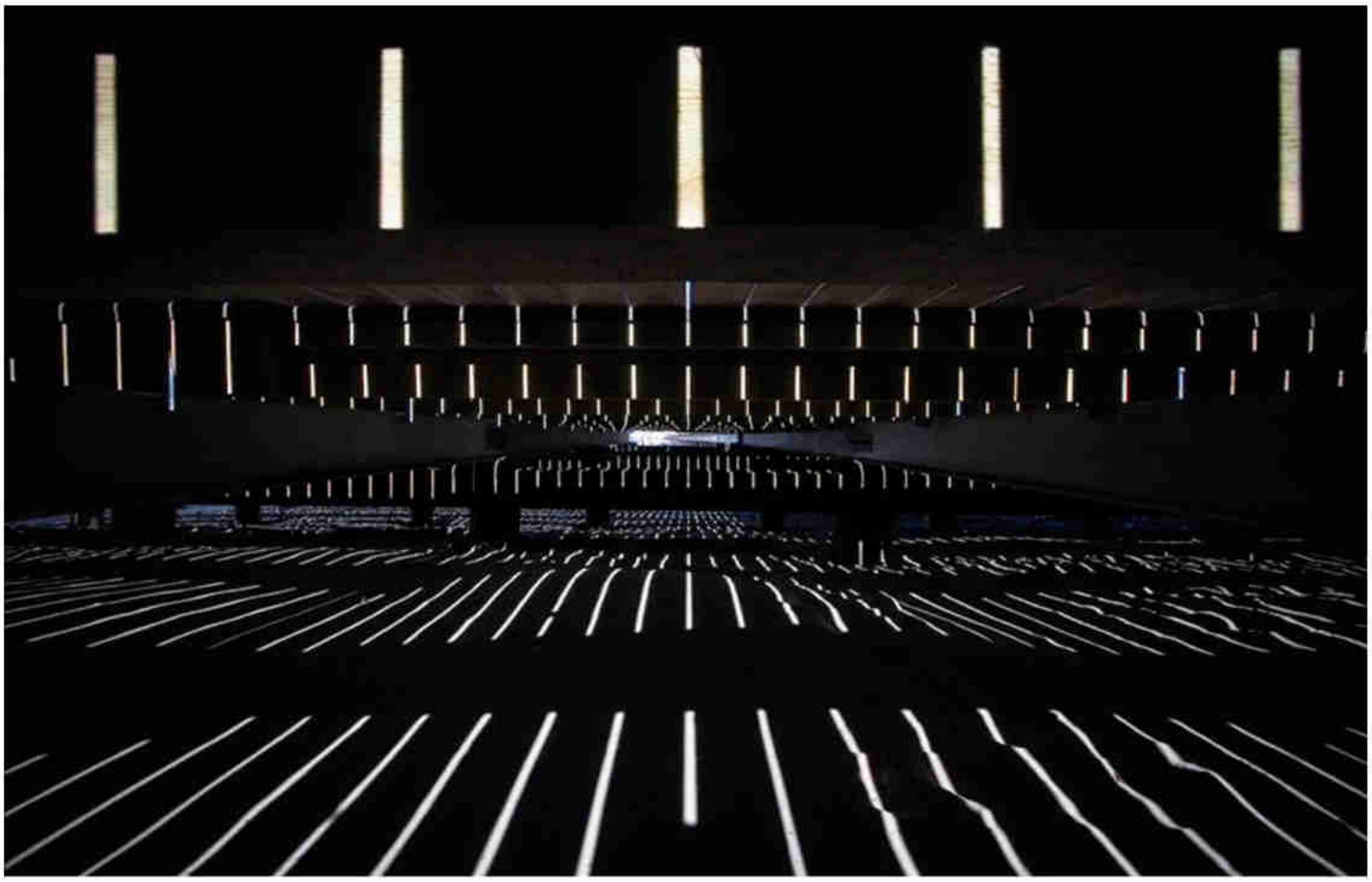
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A Different Stripe The patterning in these pictures intrigued the Your Shot judges this month. Now you can check out many of the reader-submitted photos they looked at (maybe even your own) in the Top Shots and Gallery sections on our recently redesigned Your Shot website. Go to *ngm.com/yourshot* for application forms, rules, and more information—and to see what's new.

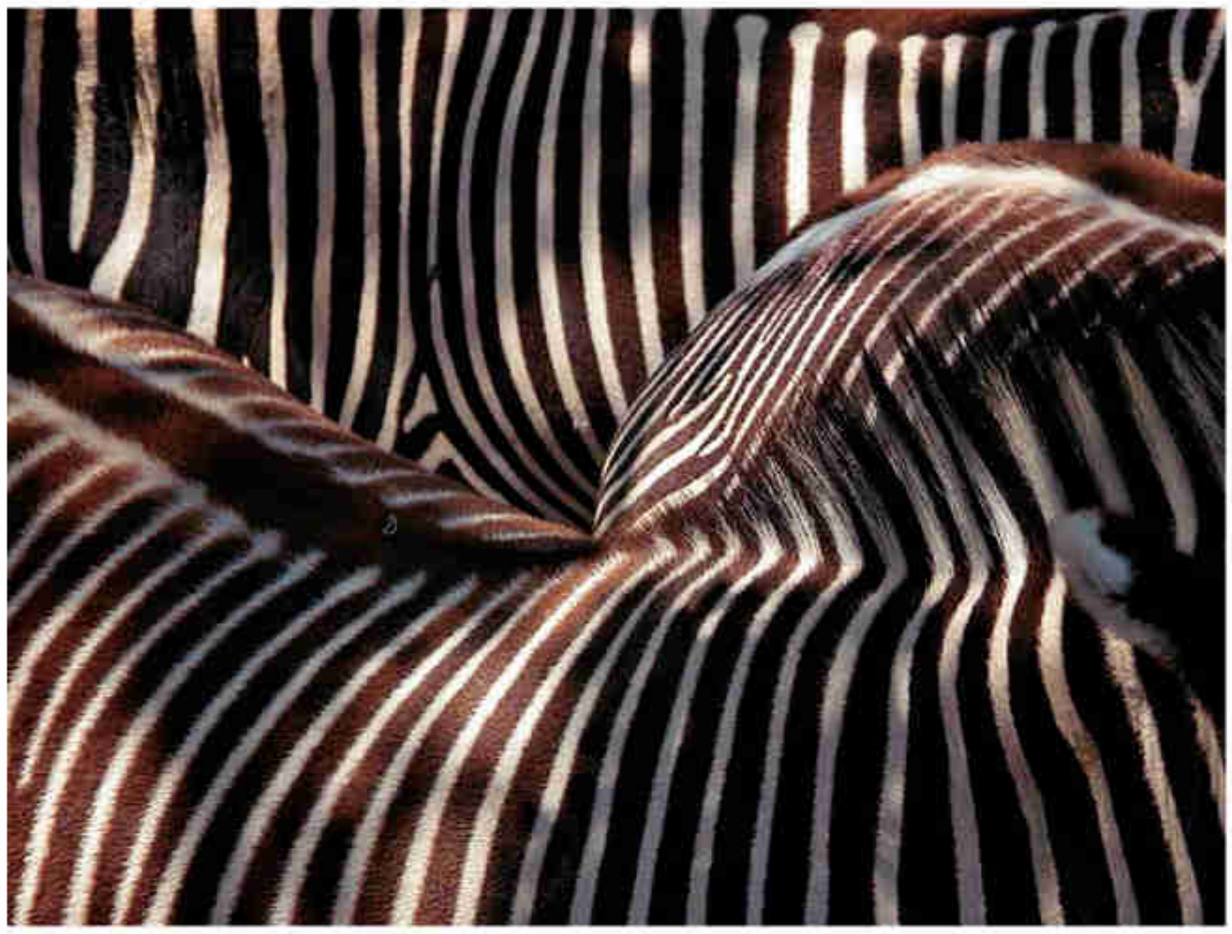


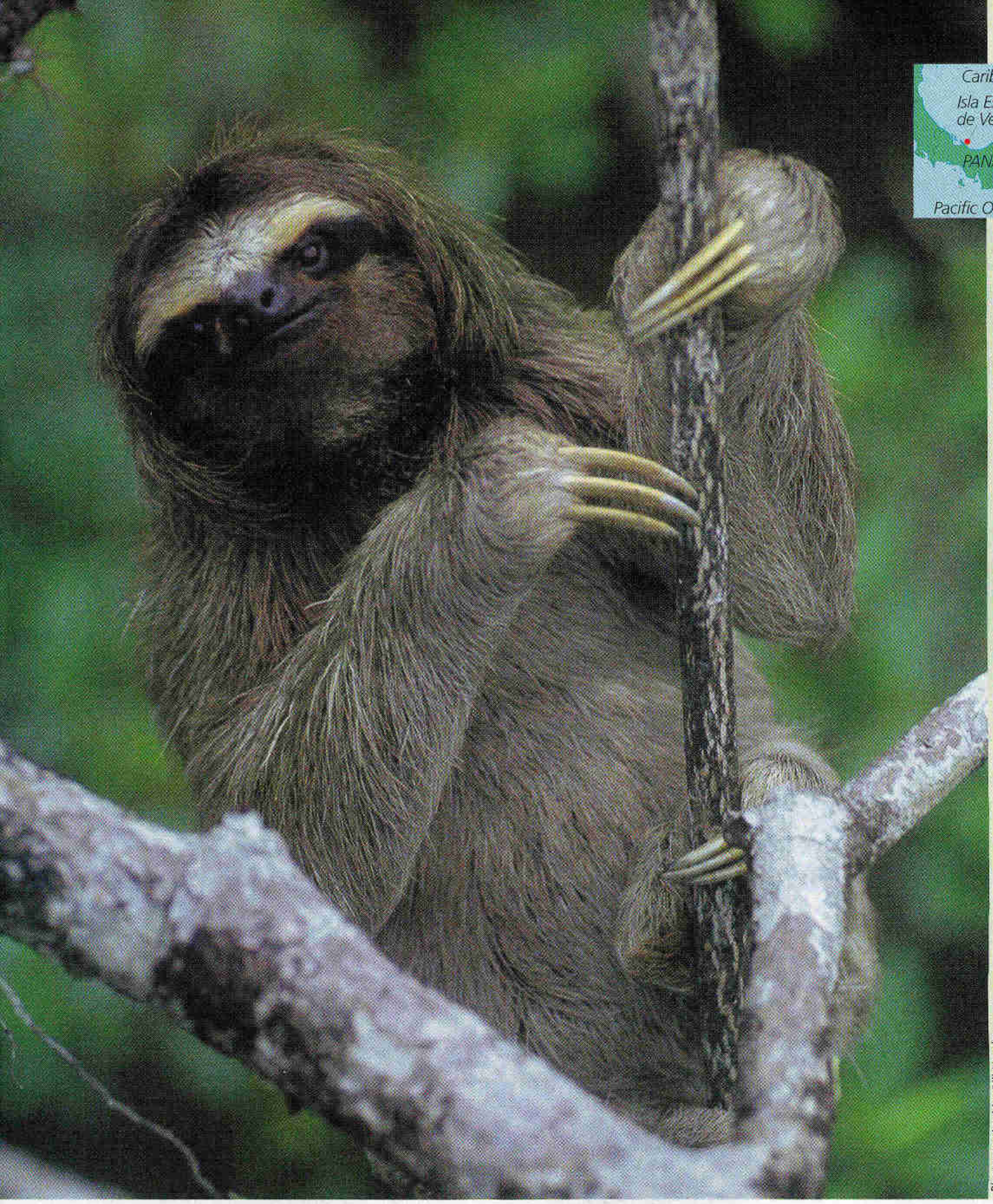
Mariusz Śmiejek Bedford, England

Capturing light filtered through a Baltic boardwalk took some effort for Mariusz Śmiejek, a photographer originally from Gniezno, Poland. When he crawled under the pier, "There was so little space, I felt the wooden planks sagging under the weight of people strolling above."

Alexandria Shankweiler Burbank, California

At the Los Angeles Zoo, "it was hot and the zebras were perfectly lined up in the shade," says Alexandria Shankweiler, a logistics manager who recently bought her first digital camera. "Now I shoot 300 to 500 shots every weekend."





Pygmy Three-toed Sloth
(Bradypus pygmaeus)

Size: Length, 19 - 21 inches; tail, 1.8 - 2.4 inches

Weight: 5.5 - 7.7 lbs

Habitat: In and near the red mangrove forests on Isla Escudo de Veraguas, the oldest and most remote island in the Bocas del Toro archipelago

Surviving number: Unknown

Photographed by Bill Hatcher

WILDLIFE AS CANON SEES IT

Sloth is a virtue. It is for the pygmy three-toed sloth, anyway, as the little tree dweller's inactivity helps it escape the notice of predators. Algae that sometimes coats its fur adds another level of camouflage. The slow-as-molasses sloth can move quickly when threatened, but generally expends no more energy than is necessary to hang around all day eating leaves. Confined to one remote island that separated from Panama long ago, this smaller cousin of mainland sloths has managed to quietly survive so far, but any disruption to its habitat could have huge consequences. The hustle and bustle of development could well be the end of it.

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This woman finds shelter in a wrecked Kabul hospital and earns a living as a prostitute on the city's battered streets.

Photographer Lana Šlezić worked in Afghanistan for two years. A collection of her award-winning images of Afghan women, Forsaken, *is published by powerHouse Books.*

Afghan Women We're all at risk of being spoon-fed a mass media vision of the world. When I left Canada in March 2004, I thought I already knew about the status of Afghan women. The Taliban had been ousted in 2001. Freedom reigned: Girls were back at school, women were no longer compelled to wear the full-length *chadri,* or burka. The heavy weight of tyranny had lifted.

It took time for me to disentangle what I expected from what I actually saw. But waiting becomes second nature in Afghanistan. Things never happen the way you expect, or as quickly as they would anywhere else. Even water for tea seems to take longer to boil. I learned to use the waiting time to take in details. To think. To listen. I spent hours, days, just sitting and talking with women in their homes. I drank a lot of tea. And with the help of a wonderful young Afghan translator, who is a photographer herself and who understands the sensitivity that's needed to earn trust, I learned a more complicated truth.

In villages and cities across the country, the popular clichés of liberation are dangerously irrelevant. Women and girls face fear every day. Many are battered wives, widows cast out of their homes, destitute refugees who risk being killed if their "honorable" families find out they've turned to prostitution to survive. Many are crusaders, too, struggling to empower their countrywomen. But for millions of Afghan women "freedom" is still just a word, barely understood and completely out of reach.









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The face of the world is changing. More people than ever are living in areas vulnerable to natural disasters. Over a billion people live under the shadow of the world's 1,900 active volcanoes, yet only a few of them are adequately monitored. Accurate forecasting is the best defense against hurricanes but landfall predictions remain inaccurate by an average of 70 miles and many hurricane warnings go unheeded. Tsunami's can form too quickly for an official warning, but recognizing the immediate signs, such as a rapidly receding ocean, can give people precious minutes to reach safety.

The science of weather is a constantly evolving field, sparking a number of breakthroughs on how to anticipate and track superstorms and other natural disasters. For average citizens, this research translates to better preparedness when faced with the unexpected. To expand your knowledge of such issues, go to **www.nationalgeographic.com.**

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Avid shoppers in a Mazar-e Sharif clothing store demonstrate that even beneath the shapeless anonymity of the chadri, the desire for style survives. Afghan President Hamid Karzai has declared that women may choose to wear the head-to-toe covering in public or not, but it remains a common sight, especially outside the capital.



Šlezić came to expect girls to shield their faces when they saw her camera. "I stepped out of a bakery on a back street in Kabul and saw these two on their way to school." The UN says a million Afghan girls who should be in school are not—adding to a female illiteracy rate that tops 80 percent.

Learn about National Geographic's Afghan Girls Fund at **nationalgeographic.com/donate/afghan_girls_fund.html.**

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"I was passing through a small village north of Kabul," Šlezić says, "and I knocked on a door." These are two of the five children she found living inside. Their mother and father were both dead. An estimated two million Afghan children have lost parents. Government-run orphanages offer refuge to just 10,000 of them.



Daughter of a policeman, Malalai Kakar joined the Kandahar police force 25 years ago. Always armed in public, the mother of six confronts the city's most violent crimes side by side with male colleagues. Šlezić saw her catch a suspected kidnapper: "She had no fear." Kakar stopped wearing the chadri in 2005.

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PHOTO JOURNAL | LANA K. ŠLEZIĆ



The floury handprints of female cooks decorate the soot-blackened walls of a mosque kitchen in Kabul. "There were ten shallow cauldrons, each over its own fire," Šlezić says. "Women came to prepare a special sweet when their prayers were answered or problems resolved. As soon as one finished cooking, another would begin."



Young girls in their dressed-up best gather for a squirming, giggling portrait during preparations for a family celebration in Kandahar. "I was a guest at the party, and I'd spent time with the family, so they were at ease with me," Šlezić recalls. "And we were in a walled courtyard —with no men around."

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IMPORTANT SAFETY INFORMATION: LUNESTA works quickly, and should be taken right before bed. Be sure you have at least eight hours to devote to sleep before becoming active. Until you know how you'll react to prescription LUNESTA, you should not drive or operate machinery. Do not use alcohol while taking LUNESTA. Most sleep medicines carry some risk of dependency. Side effects may include unpleasant taste, headache, drowsiness and dizziness. See important patient information on the next page.

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Lunesta™ (eszopiclone) C-IV

1, 2 AND 3 MG TABLETS

Please read this summary of information about LUNESTA before you talk to your doctor or start using LUNESTA. It is not meant to take the place of your doctor's instructions. If you have any questions about LUNESTA tablets, be sure to ask your doctor or pharmacist.

LUNESTA is used to treat different types of sleep problems, such as difficulty in falling asleep, difficulty in maintaining sleep during the night, and waking up too early in the morning. Most people with insomnia have more than one of these problems. You should take LUNESTA immediately before going to bed because of the risk of falling.

LUNESTA belongs to a group of medicines known as "hypnotics" or, simply, sleep medicines. There are many different sleep medicines available to help people sleep better. Insomnia is often transient and intermittent. It usually requires treatment for only a short time, usually 7 to 10 days up to 2 weeks. If your insomnia does not improve after 7 to 10 days of treatment, see your doctor, because it may be a sign of an underlying condition. Some people have chronic sleep problems that may require more prolonged use of sleep medicine. However, you should not use these medicines for long periods without talking with your doctor about the risks and benefits of prolonged use.

Side Effects

All medicines have side effects. The most common side effects of sleep medicines are:

- Drowsiness
- Dizziness
- Lightheadedness
- Difficulty with coordination

Sleep medicines can make you sleepy during the day. How drowsy you feel depends upon how your body reacts to the medicine, which sleep medicine you are taking, and how large a dose your doctor has prescribed. Daytime drowsiness is best avoided by taking the lowest dose possible that will still help you sleep at night. Your doctor will work with you to find the dose of LUNESTA that is best for you. Some people taking LUNESTA have reported next-day sleepiness.

To manage these side effects while you are taking this medicine:

- When you first start taking LUNESTA or any other sleep medicine, until you know whether the medicine will still have some effect on you the next day, use extreme care while doing anything that requires complete alertness, such as driving a car, operating machinery, or piloting an aircraft.
- Do not drink alcohol when you are taking LUNESTA or any sleep medicine. Alcohol can increase the side effects of LUNESTA or any other sleep medicine.
- Do not take any other medicines without asking your doctor first. This includes medicines you can buy without a prescription. Some medicines can cause drowsiness and are best avoided while taking LUNESTA.
- Always take the exact dose of LUNESTA prescribed by your doctor. Never change your dose without talking to your doctor first.

Special Concerns

There are some special problems that may occur while taking sleep medicines.

Memory Problems

Sleep medicines may cause a special type of memory loss or "amnesia." When this occurs, a person may not remember what has happened for several hours after taking the medicine. This is usually not a problem since most people fall asleep after taking the medicine. Memory loss can be a problem, however, when sleep medicines are taken while traveling, such as during an airplane flight and the person wakes up before the effect of the medicine is gone. This has been called "traveler's amnesia." Memory problems have been reported rarely by patients taking LUNESTA in clinical studies. In most cases, memory problems can be avoided if you take LUNESTA only when you are able to get a full night of sleep before you need to be active again. Be sure to talk to your doctor if you think you are having memory problems.

Tolerance

When sleep medicines are used every night for more than a few weeks, they may lose their effectiveness in helping you sleep. This is known as "tolerance." Development of tolerance to LUNESTA was not observed in a clinical study of 6 months' duration. Insomnia is often transient and intermittent, and prolonged use of sleep medicines is generally not necessary. Some people, though, have chronic sleep problems that may require more prolonged use of sleep medicine. If your sleep problems continue, consult your doctor, who will determine whether other measures are needed to overcome your sleep problems.

Dependence

Sleep medicines can cause dependence in some people, especially when these medicines are used regularly for longer than a few weeks or at high doses. Dependence is the need to continue taking a medicine because stopping it is unpleasant. When people develop dependence, stopping the medicine suddenly may cause unpleasant symptoms (see *Withdrawal* below). They may find they have to keep taking the medicine either at the prescribed dose or at increasing doses just to avoid withdrawal symptoms.

All people taking sleep medicines have some risk of becoming dependent on the medicine. However, people who have been dependent on alcohol or other drugs in the past may have a higher chance of becoming addicted to sleep medicines. This possibility must be considered before using these medicines for more than a few weeks. If you have been addicted to alcohol or drugs in the past, it is important to tell your doctor before starting LUNESTA or any sleep medicine.

Withdrawal

Withdrawal symptoms may occur when sleep medicines are stopped suddenly after being used daily for a long time. In some cases, these symptoms can occur even if the medicine has been used for only a week or two. In mild cases, withdrawal symptoms may include unpleasant feelings. In more severe cases, abdominal and muscle cramps, vomiting, sweating, shakiness, and, rarely, seizures may occur. These more severe withdrawal symptoms are very uncommon. Although withdrawal symptoms have not been observed in the relatively limited controlled trials experience with LUNESTA, there is, nevertheless, the risk of such events in association with the use of any sleep medicine.

Another problem that may occur when sleep medicines are stopped is known as "rebound insomnia." This means that a person may have more trouble sleeping the first few nights after the medicine is stopped than before starting the medicine. If you should experience rebound insomnia, do not get discouraged. This problem usually goes away on its own after 1 or 2 nights.

If you have been taking LUNESTA or any other sleep medicine for more than 1 or 2 weeks, do not stop taking it on your own. Always follow your doctor's directions.

Changes In Behavior And Thinking

Some people using sleep medicines have experienced unusual changes in their thinking and/or behavior. These effects are not common. However, they have included:

- More outgoing or aggressive behavior than normal
- Confusion
- Strange behavior
- Agitation
- Hallucinations
- Worsening of depression
- Suicidal thoughts

How often these effects occur depends on several factors, such as a person's general health, the use of other medicines, and which sleep medicine is being used. Clinical experience with LUNESTA suggests that it is rarely associated with these behavior changes.

It is also important to realize it is rarely clear whether these behavior changes are caused by the medicine, are caused by an illness, or have occurred on their own. In fact, sleep problems that do not

improve may be due to illnesses that were present before the medicine was used. If you or your family notice any changes in your behavior, or if you have any unusual or disturbing thoughts, call your doctor immediately.

Pregnancy And Breastfeeding

Sleep medicines may cause sedation or other potential effects in the unborn baby when used during the last weeks of pregnancy. Be sure to tell your doctor if you are pregnant, if you are planning to become pregnant, or if you become pregnant while taking LUNESTA.

In addition, a very small amount of LUNESTA may be present in breast milk after use of the medication. The effects of very small amounts of LUNESTA on an infant are not known; therefore, as with all other prescription sleep medicines, it is recommended that you not take LUNESTA if you are breastfeeding a baby.

Safe Use Of Sleep Medicines

To ensure the safe and effective use of LUNESTA or any other sleep medicine, you should observe the following cautions:

1. LUNESTA is a prescription medicine and should be used ONLY as directed by your doctor. Follow your doctor's instructions about how to take, when to take, and how long to take LUNESTA.
2. Never use LUNESTA or any other sleep medicine for longer than directed by your doctor.
3. If you notice any unusual and/or disturbing thoughts or behavior during treatment with LUNESTA or any other sleep medicine, contact your doctor.
4. Tell your doctor about any medicines you may be taking, including medicines you may buy without a prescription and herbal preparations. You should also tell your doctor if you drink alcohol. DO NOT use alcohol while taking LUNESTA or any other sleep medicine.
5. Do not take LUNESTA unless you are able to get 8 or more hours of sleep before you must be active again.
6. Do not increase the prescribed dose of LUNESTA or any other sleep medicine unless instructed by your doctor.
7. When you first start taking LUNESTA or any other sleep medicine, until you know whether the medicine will still have some effect on you the next day, use extreme care while doing anything that requires complete alertness, such as driving a car, operating machinery, or piloting an aircraft.
8. Be aware that you may have more sleeping problems the first night or two after stopping any sleep medicine.
9. Be sure to tell your doctor if you are pregnant, if you are planning to become pregnant, if you become pregnant, or if you are breastfeeding a baby while taking LUNESTA.
10. As with all prescription medicines, never share LUNESTA or any other sleep medicine with anyone else. Always store LUNESTA or any other sleep medicine in the original container and out of reach of children.
11. Be sure to tell your doctor if you suffer from depression.
12. LUNESTA works very quickly. You should only take LUNESTA immediately before going to bed.
13. For LUNESTA to work best, you should not take it with or immediately after a high-fat, heavy meal.
14. Some people, such as older adults (i.e., ages 65 and over) and people with liver disease, should start with the lower dose (1 mg) of LUNESTA. Your doctor may choose to start therapy at 2 mg. In general, adults under age 65 should be treated with 2 or 3 mg.
15. Each tablet is a single dose; do not crush or break the tablet.

Note: This summary provides important information about LUNESTA. If you would like more information, ask your doctor or pharmacist to let you read the Prescribing Information and then discuss it with him or her.

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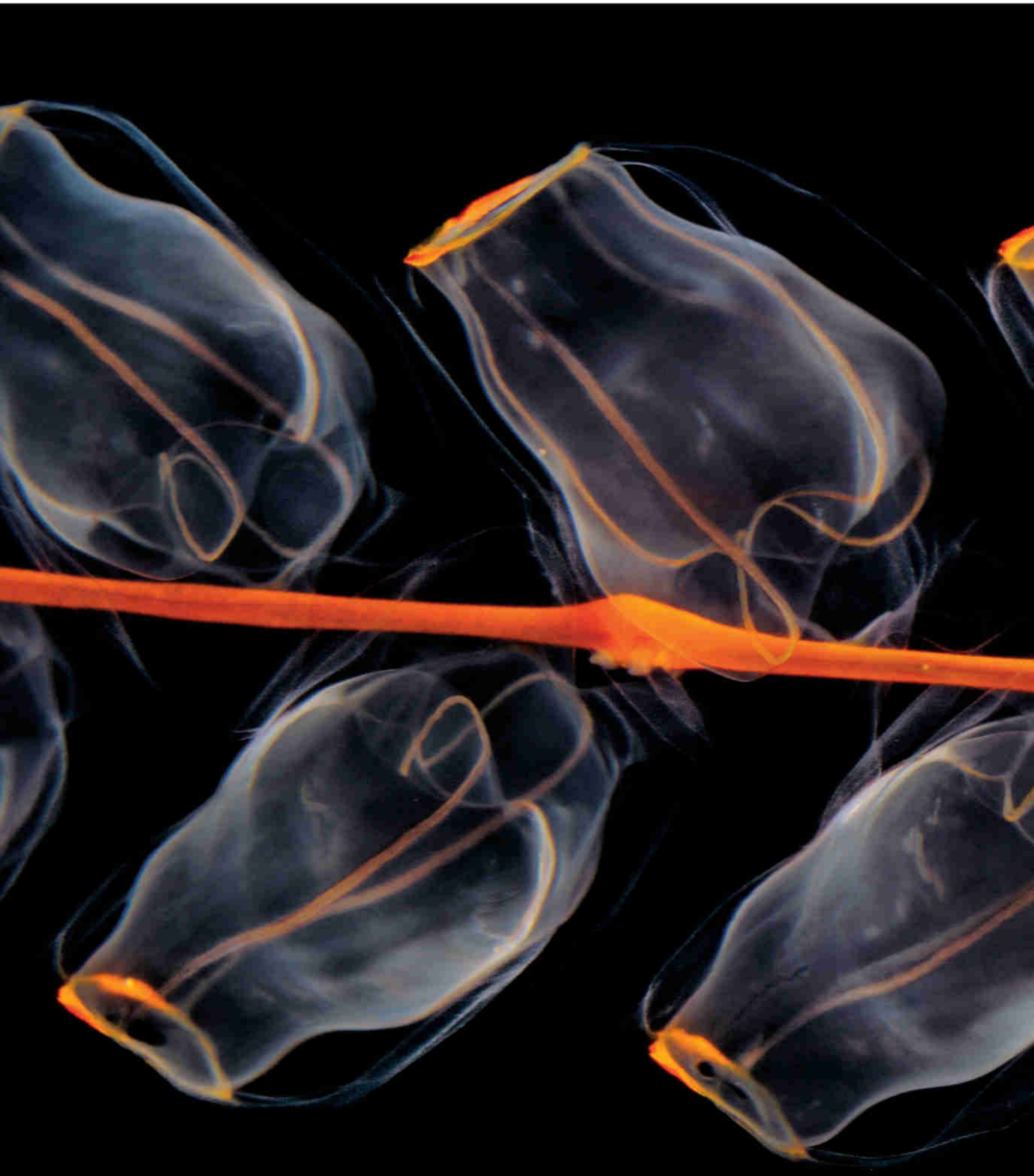


India The blue walls of Jodhpur traditionally marked homes occupied by high-caste Brahmans. The rooftop langurs, believed by Hindus to be avatars of the monkey god Hanuman, freely roam the city.

PHOTO: JEAN-PIERRE ZWAENEPOEL



Arctic Ocean Looking like a rack of blown-glass vases, inch-long swimming bells of a siphonophore—a jellyfish relative called *Marrus orthocanna*—hang from a tubular stem that delivers nutrients to the bells.



THIS IMAGE WAS MADE AS A VERTICAL BUT IS ORIENTED HORIZONTALLY HERE. PHOTO: KEVIN RASKOFF, MONTEREY PENINSULA COLLEGE

South Dakota Erupting into a flapping liftoff frenzy when menaced by hawks overhead, nearly a thousand mallards—flashy males and subtler females—congregated on this Tuthill pond last winter.



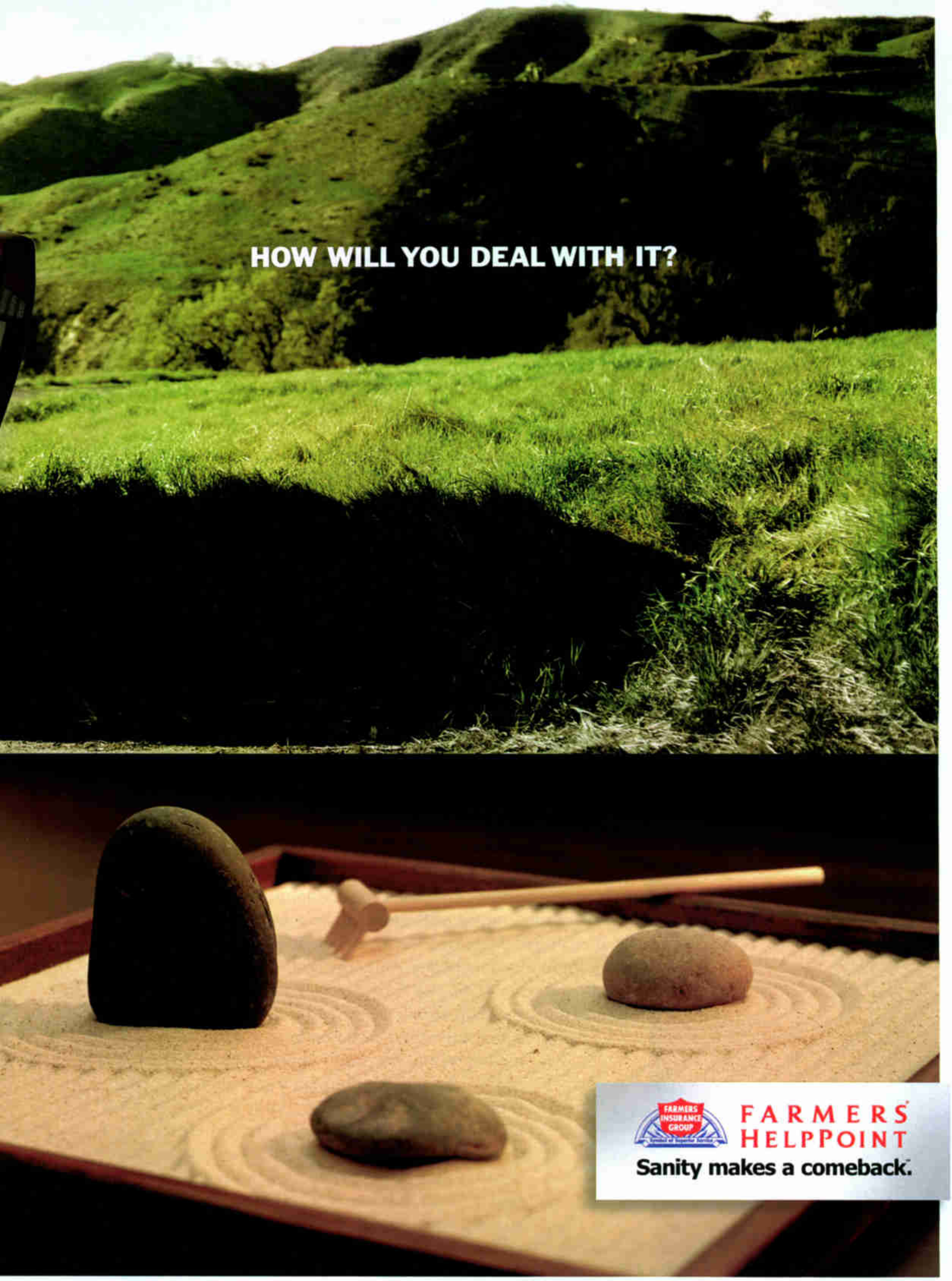
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This clouded leopard on Borneo is getting its own species name: *Neofelis diardi*.

Leopard Imprint After a very long delay, the clan of cats is welcoming another species. Clouded leopards are reclusive denizens of the jungles of Southeast Asia and nearby islands. In 1823, a zoologist described the island cat as its own species; later it was demoted to a subspecies. But new analysis shows the clouded leopards of Borneo (and also Sumatra) are a bit darker than their mainland cousins, with smaller cloud-shaped markings. What's more, the island and mainland felines are genetically as different as lions and tigers. Zoos in Thailand and the U.S. are cooperating on a captive-breeding program for the mainland cat, but few island cats are in captivity. Staying mainly in trees, they are rarely seen in the wild; estimates vary, but several thousand could live in Borneo. Poaching and deforestation threaten both species; the three countries that share Borneo have set aside the Heart of Borneo, an area that will allow some agriculture but also leave space for animals to thrive. *—Helen Fields*



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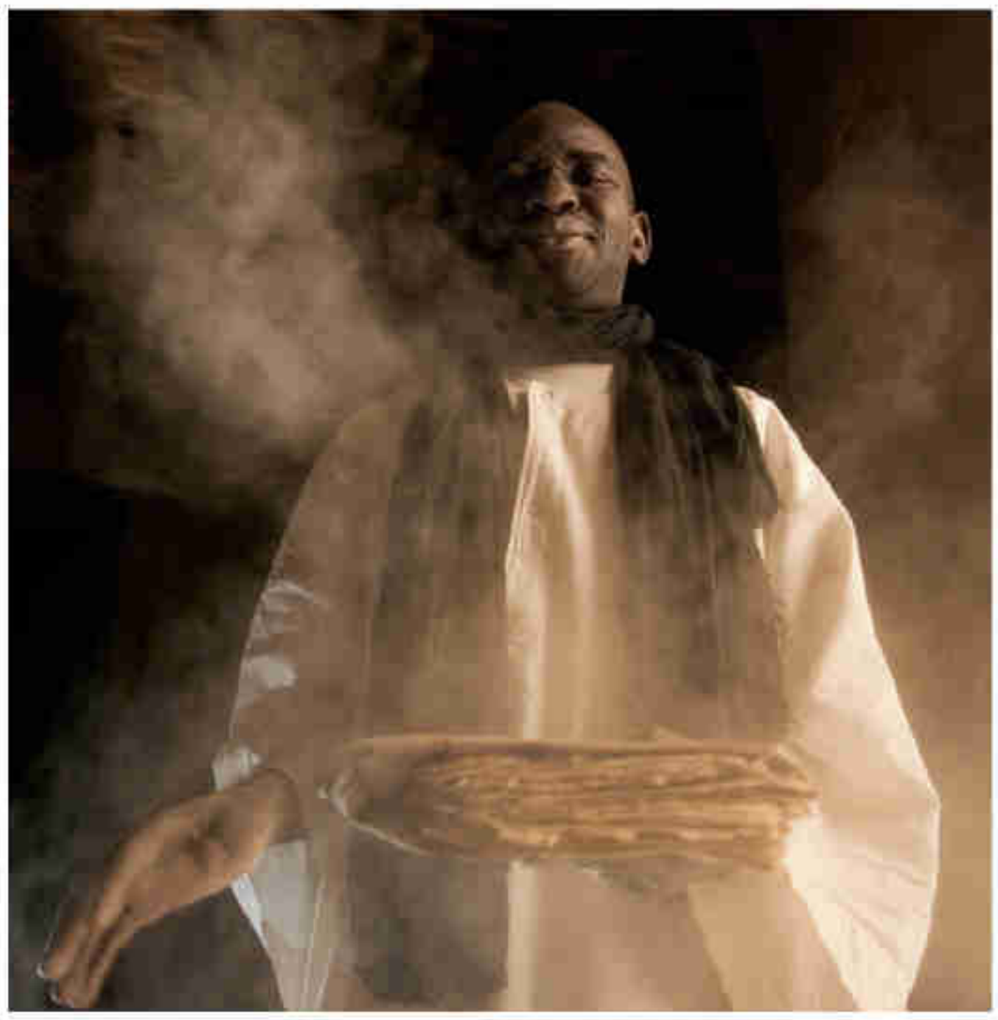
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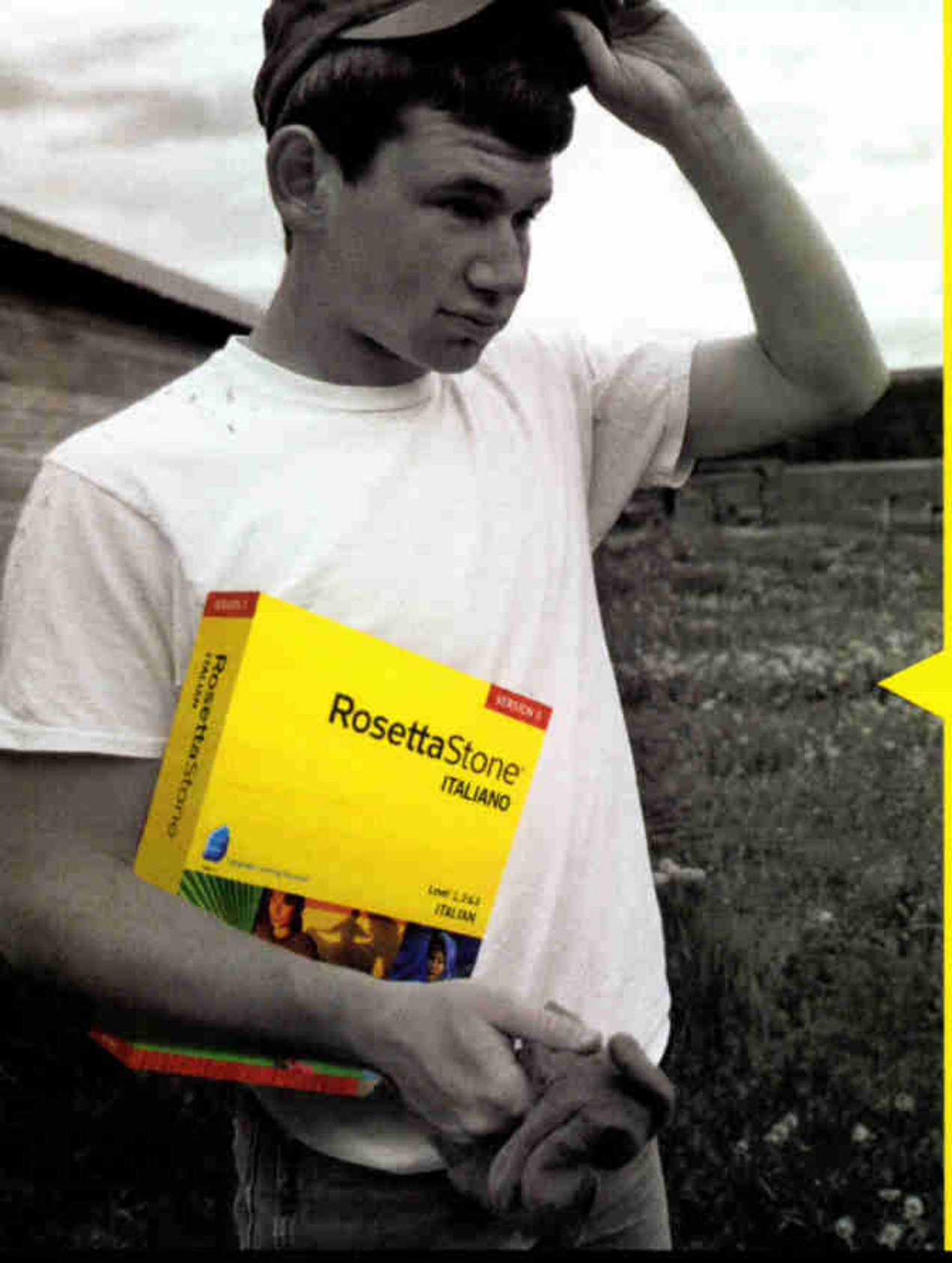
Page Protectors In the 1500s Mohammed El Mawlud began collecting manuscripts in a village on the Sahara's edge. He was one of many scholars, scribes, and saints around Timbuktu who both bought and created handwritten texts, in Arabic script, on topics from theology to astronomy. In 1591 a Moroccan army sacked the center of learning, destroying some texts, carrying off others. Families hid what they could behind walls and in caves. Fire, theft, and termites took a toll, yet 300,000 books survived. In the 1990s Western academics realized the library's extent. Grants are helping repair, protect, and scan the volumes, which date from the 12th century. A research institute now houses some 30,000, but most remain with the families that long guarded them. Generations after El Mawlud, descendant Abdel Kader Haidara has built the Mamma Haidara Library, named for his father, for his 9,000 texts. "These manuscripts," says Haidara, "are our dignity." *—Karen E. Lange*





Many families in Timbuktu preserve old tomes. A book on religion (top) is one of 9,000 held by descendants of Mohammed El Mawlud. Boubacar Sadeck (above) holds a dusty text that his ancestors sheltered.

PHOTOS: AMI VITALE. NGM MAPS



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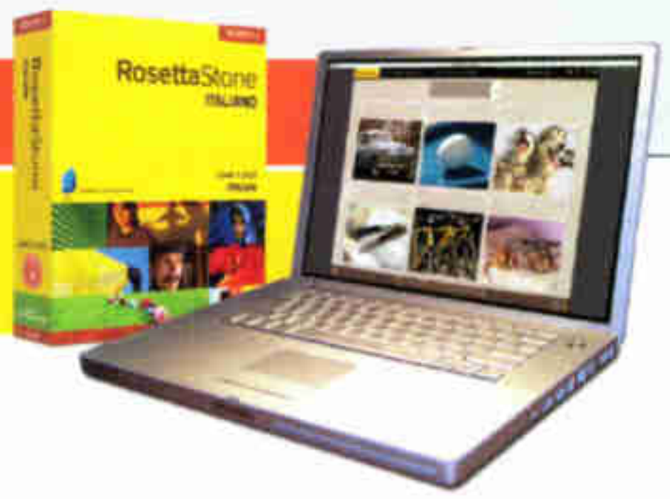
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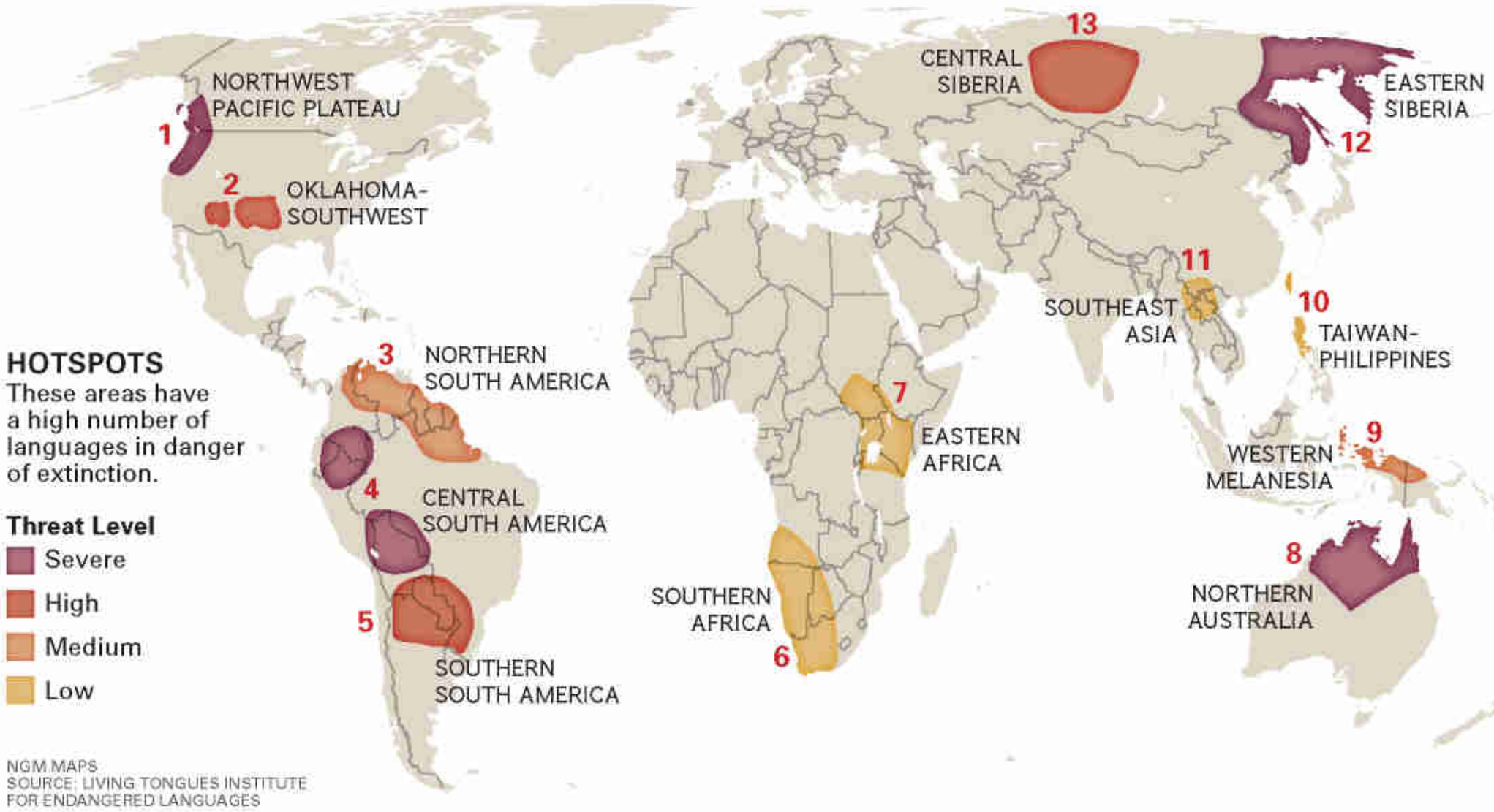
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- South Haida 10

2 Oklahoma-Southwest
- Cahuilla 20
- Mohave 7
- Wichita 3

3 Northern South America
- Tinigua 2
- Totoro 5
- Zaparo 5

4 Central South America
- Muniche 5
- Taushiro 1
- Uru 1

5 Southern South America
- Guató 50
- Ofaye 20
- Vilela 2

6 Southern Africa
- Nlu ("!" is a click) 8
- Tswapong 2,000
- Xiri 85



In her traditional Monchak language, this western Mongolian grandmother (above) has no word for "grandson" but several for goats with different colors or markings. That richness of vocabulary is typical of herders. She is one of the last speakers of the ancient tongue. Her grandson knows only Mongolian; within his lifetime, Monchak will be extinct. The Living Tongues Institute for Endangered Languages is working with National Geographic's Enduring Voices Project to map linguistic hotspots so resources can be directed to record fading languages and help those that can be saved. —*A. R. Williams*

7 Eastern Africa
- Ngasa 300
- Nindi 100
- Omotik 50

8 Northern Australia
- Gurdanji 5
- Marti Ke 10
- Nyikina 50

9 Western Melanesia
- Piru 10
- Usku 25
- Woria 10

10 Taiwan-Philippines
- Arta 5
- Babuza 5
- Pazeh 1

11 Southeast Asia
- Arem 40
- Buxinhua 200
- Red Gelao 20

12 Eastern Siberia
- Medny Aleut 20
- Orok 20
- Tundra Yukaghir 50

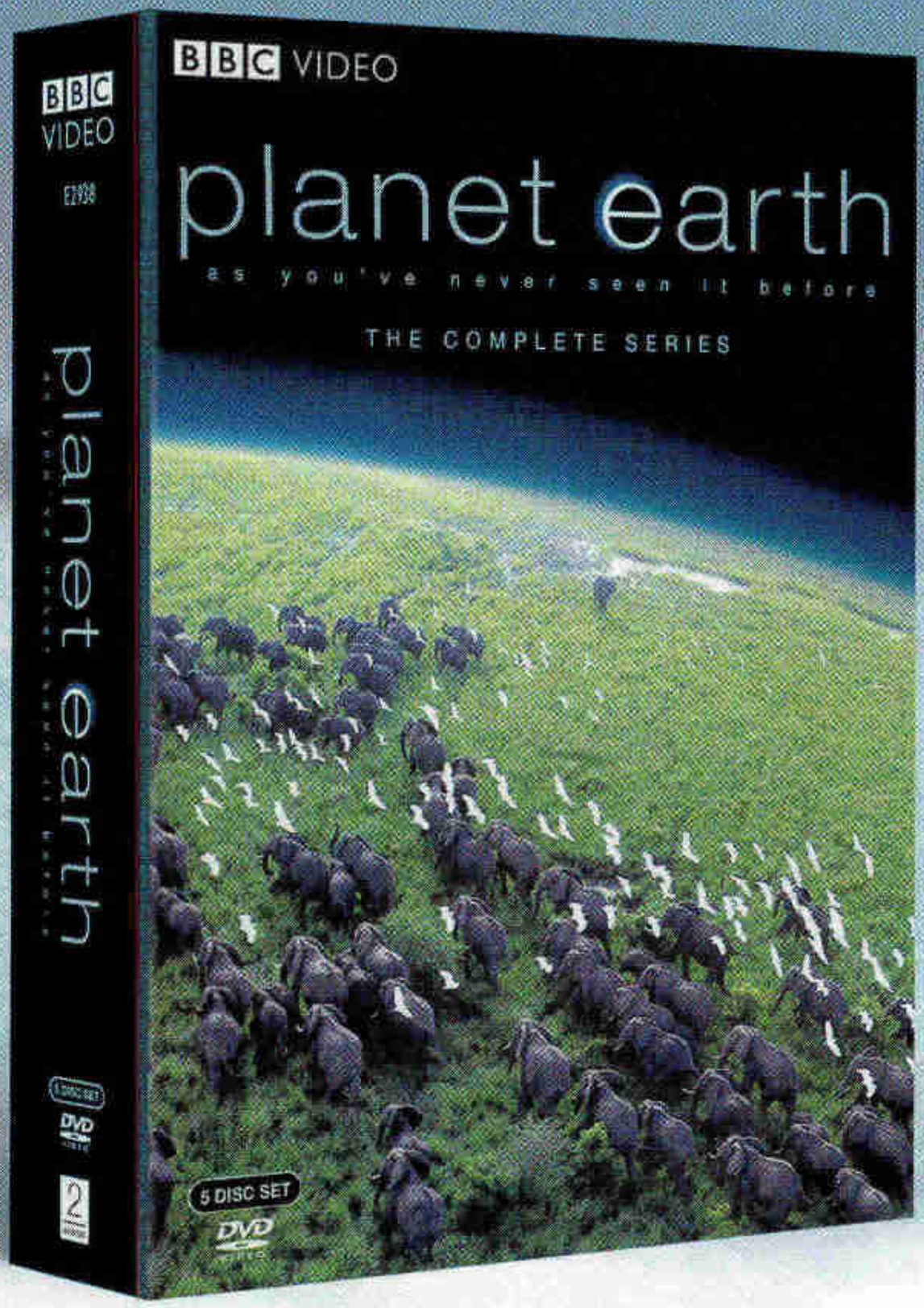
13 Central Siberia
- Enets 50
- Ös 15
- South Selkup 20

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PHOTO: KELLY RICHARDSON

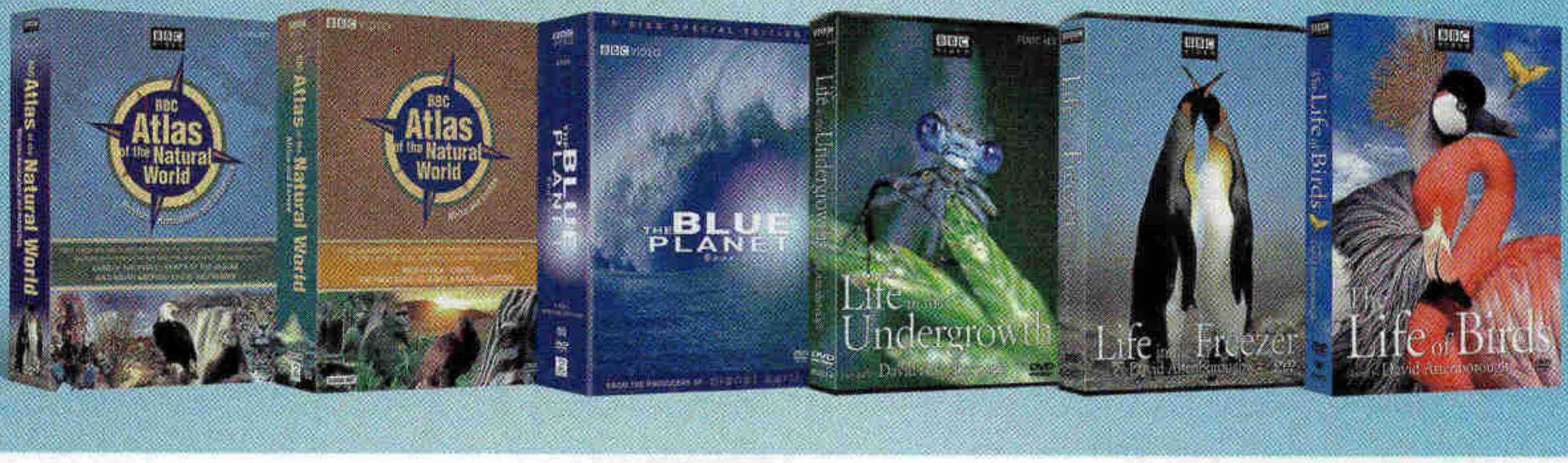
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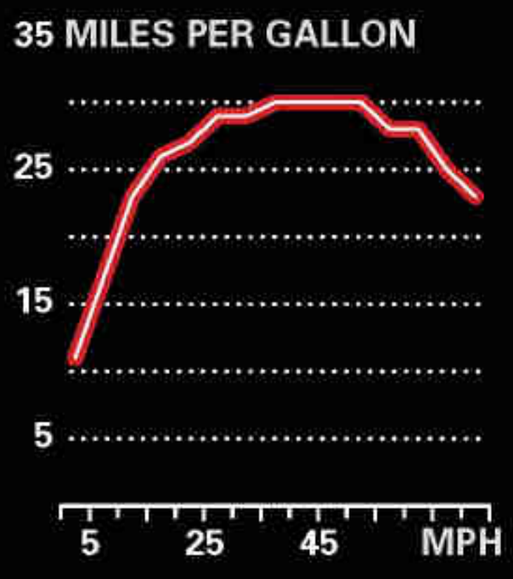
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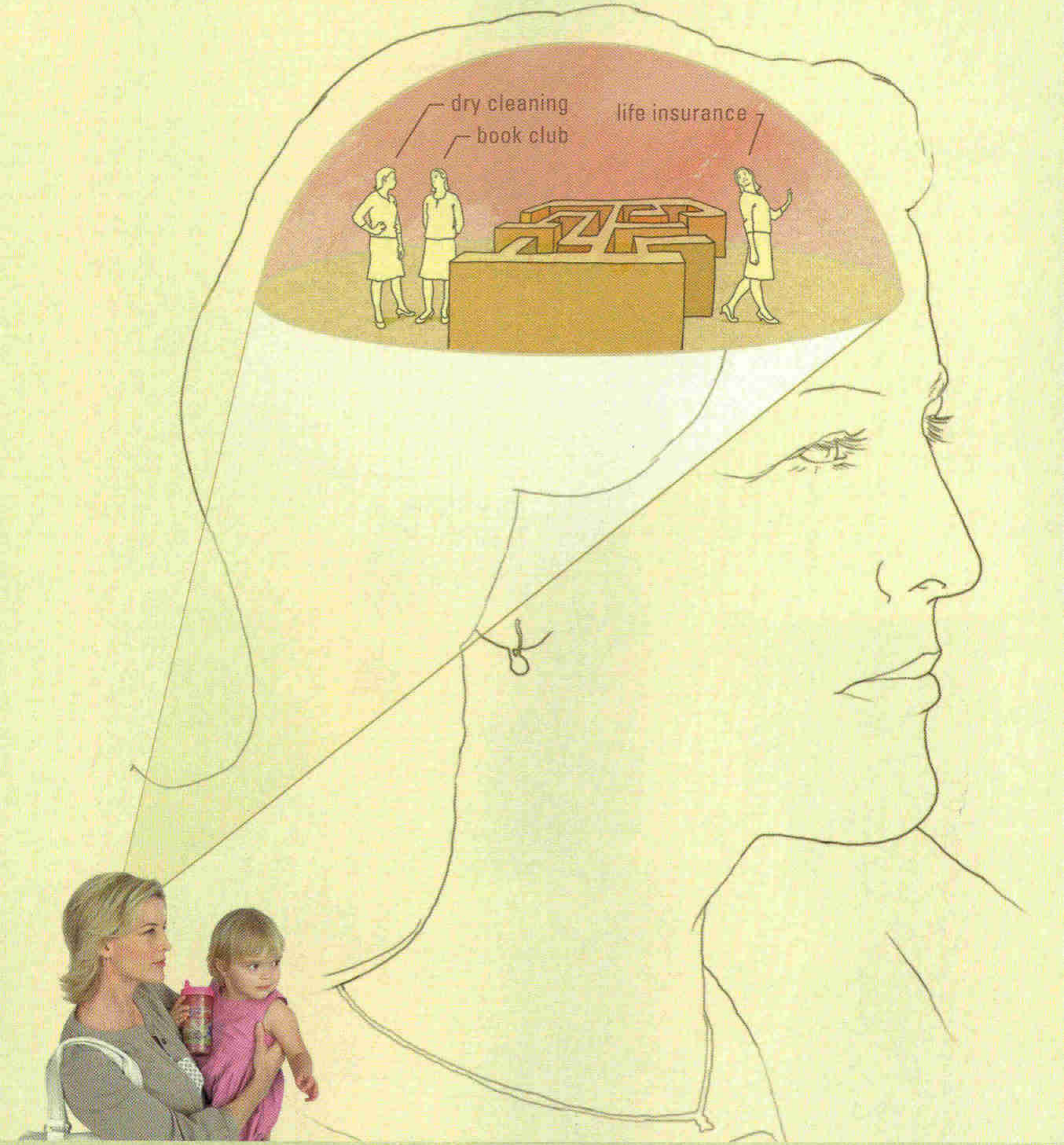
PEAK PERFORMANCE
A U.S. Department of Transportation study averaged the fuel-efficiency curve for eight cars and light trucks.



Teutonic Shift Freedom to speed is an inalienable right in Germany—at least on those portions of the nearly 8,000 miles of autobahn that have no posted limit. Some drivers well exceed 150 mph. So there was an uproar when a European Union official suggested last year that Germany cut greenhouse emissions by imposing a limit of 75 mph or so on the entire expressway.

The idea has merit. Cars burn fuel to overcome friction, air resistance, and other forces allied against them. The more fuel a car burns, the more CO_2 it produces. Every car has a peak fuel-efficient speed that gains the greatest distance per unit of energy spent. That speed varies by make and model, but according to David L. Greene, a corporate research fellow at Tennessee's National Transportation Research Center, "there would be very few cars with an optimal speed above 70 mph." Still, an autobahn limit might not be a huge help. Even now, its drivers average around 80 mph. *—Tom Zeller, Jr.*

PHOTO: NICK KELSH



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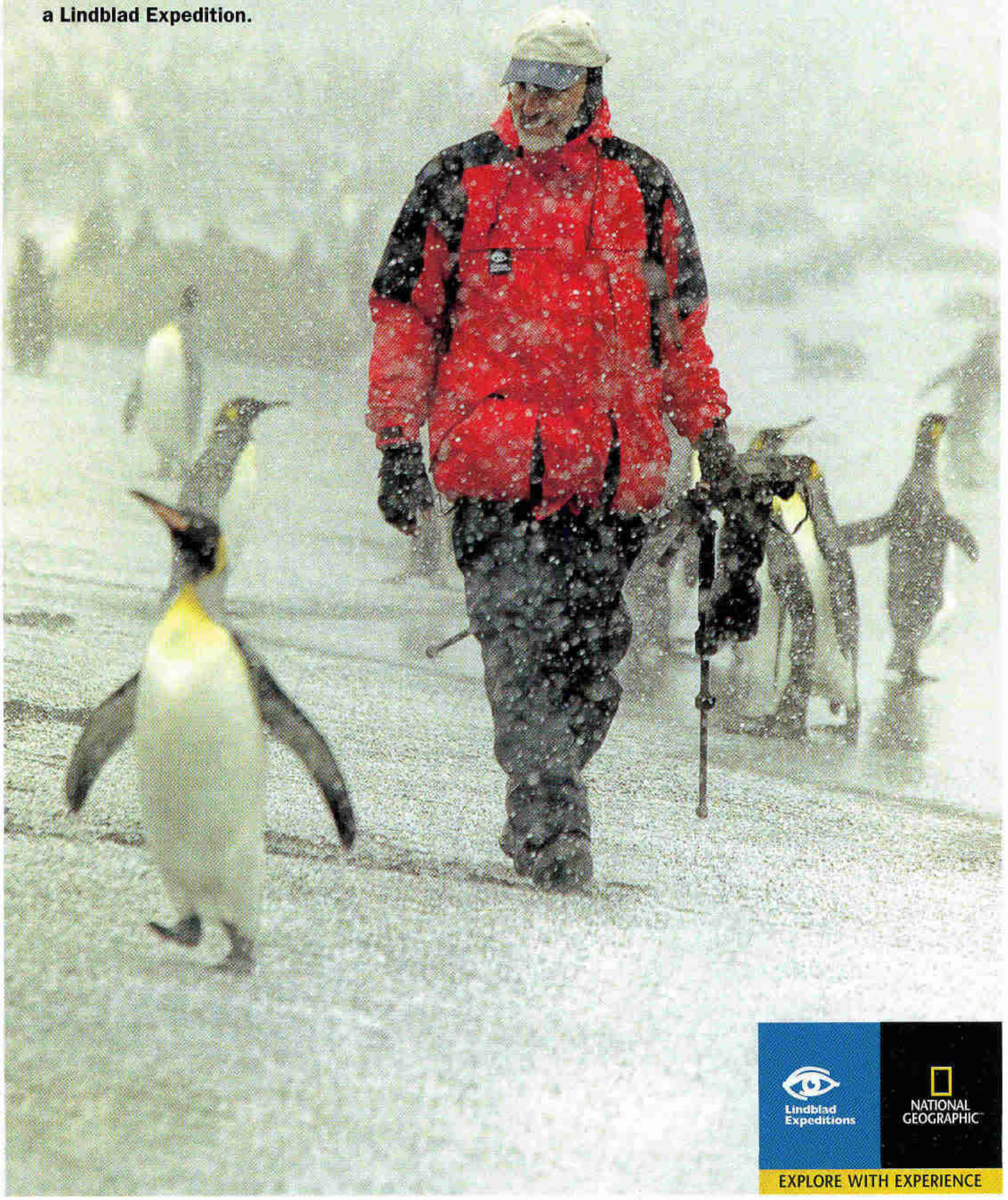
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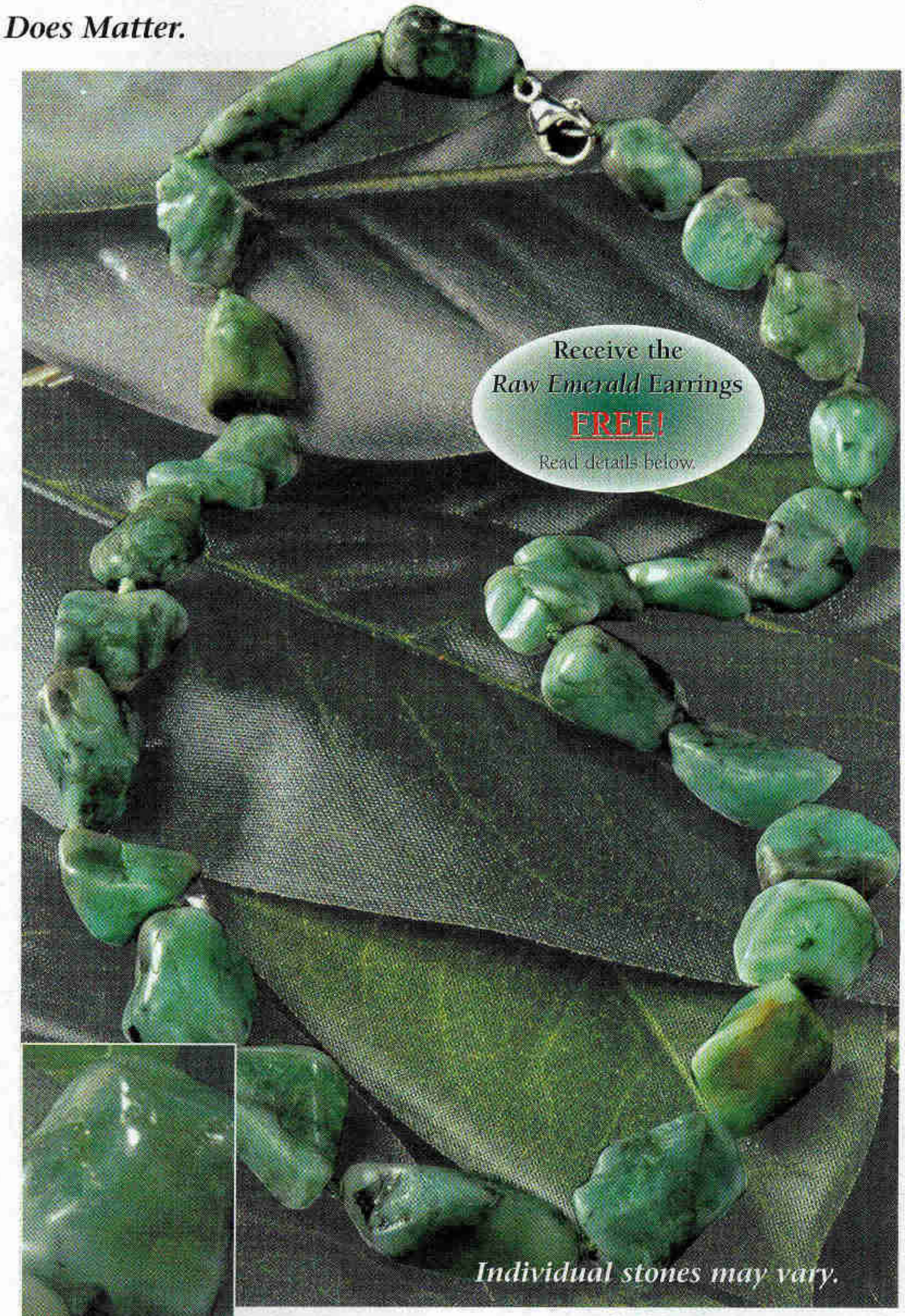
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The Anatomy of Painless Pecking

If we humans went around banging our heads against trees, nasty headaches, detached retinas, and concussions could result. Hardly worth it for a mouthful of bugs. But woodpeckers are suited to the task, and doctors who study head trauma are trying to learn how the birds avoid injury. One study shows that woodpecker eyes are held tightly in place by bone and surrounding tissue, unlike human eyes, which have room to move around within the sockets. The bird has other adaptations (above). But a question remains: Do woodpeckers get headaches? "There is no way to know," admits Ivan Schwab, an ophthalmologist at University of California, Davis, who studies woodpeckers as a hobby. Then again, he notes, animals usually avoid doing things that hurt. *—Helen Fields*



Great spotted woodpecker *(Dendrocopos major)*

ART: BRUCE MORSER. PHOTO: TORSTEN SCHROEER, BLICKWINKEL/ALAMY

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AMBIEN CR is a treatment option you and your healthcare provider can consider along with lifestyle changes and can be taken for as long as your provider recommends. Until you know how AMBIEN CR will affect you, you shouldn't drive or operate machinery. Be sure you're able to devote 7 to 8 hours to sleep before being active again. Sleepwalking, and eating or driving while not fully awake, with amnesia for the event, have been reported. If you experience any of these behaviors contact your provider immediately. In rare cases, sleep medicines may cause allergic reactions such as swelling of your tongue or throat, shortness of breath or more severe results. If you have an allergic reaction while using AMBIEN CR, contact your doctor immediately. Side effects may include next-day drowsiness, dizziness and headache. It's non-narcotic; however, like most sleep medicines, it has some risk of dependency. Don't take it with alcohol.

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INFORMATION FOR PATIENTS TAKING AMBIEN CR

Your doctor has prescribed Ambien CR to help you sleep. The following information is intended to guide you in the safe use of this medicine. It is not meant to take the place of your doctor's instructions. If you have any questions about Ambien CR tablets be sure to ask your doctor or pharmacist.

Ambien CR is used to treat different types of sleep problems, such as:

- trouble falling asleep
- waking up often during the night

Some people may have more than one of these problems.

Ambien CR belongs to a group of medicines known as the "sedative/hypnotics", or simply, sleep medicines. There are many different sleep medicines available to help people sleep better. Sleep problems are usually temporary, requiring treatment for only a short time, usually 1 or 2 days up to 1 or 2 weeks. Some people have chronic sleep problems that may require more prolonged use of sleep medicine. However, you should not use these medicines for long periods without talking with your doctor about the risks and benefits of prolonged use.

SIDE EFFECTS

Most common side effects:

- headache
- somnolence (sleepiness)
- dizziness

You may find that these medicines make you sleepy during the day. How drowsy you feel depends upon how your body reacts to the medicine, which sleep medicine you are taking, and how large a dose your doctor has prescribed. Daytime drowsiness is best avoided by taking the lowest dose possible that will still help you sleep at night. Your doctor will work with you to find the dose of Ambien CR that is best for you.

To manage these side effects while you are taking this medicine:

- When you first start taking Ambien CR or any other sleep medicine until you know whether the medicine will still have some carryover effect in you the next day, use extreme care while doing anything that requires complete alertness, such as driving a car, operating machinery, or piloting an aircraft.
- NEVER drink alcohol while you are being treated with Ambien CR or any sleep medicine. Alcohol can increase the side effects of Ambien CR or any other sleep medicine.
- Do not take any other medicines without asking your doctor first. This includes medicines you can buy without a prescription. Some medicines can cause drowsiness and are best avoided while taking Ambien CR.
- Always take the exact dose of Ambien CR prescribed by your doctor. Never change your dose without talking to your doctor first.

SPECIAL CONCERNS

There are some special problems that may occur while taking sleep medicines.

"Sleep-Driving" and other complex behaviors: There have been reports of people getting out of bed after taking a sleep medicine and driving their cars while not fully awake, often with no memory of the event. If you experience such an event, it should be reported to your doctor immediately, since "sleep-driving" can be dangerous. This behavior is more likely to occur when Ambien CR is taken with alcohol or other drugs such as those for the treatment of depression or anxiety. Other complex behaviors such as preparing and eating food, making phone calls, or having sex have been reported in people who are not fully awake after taking a sleep medicine. As with "sleep-driving", people usually do not remember these events.

Memory problems: Sleep medicines may cause a special type of memory loss or "amnesia." When this occurs, a person may not remember what has happened for several hours after taking the medicine. This is usually not a problem since most people fall asleep after taking the medicine.

Memory loss can be a problem, however, when sleep medicines are taken while traveling, such as during an airplane flight and the person wakes up before the effect of the medicine is gone. This has been called "traveler's amnesia."

Be sure to talk to your doctor if you think you are having memory problems. Although memory problems are not very common while taking Ambien CR, in most instances, they can be avoided if you take Ambien CR only when you are able to get a full night's sleep (7 to 8 hours) before you need to be active again.

Tolerance: When sleep medicines are used every night for more than a few weeks, they may lose their effectiveness to help you sleep. This is known as "tolerance". Sleep medicines should, in most cases, be used only for short periods of time, such as 1 or 2 days and generally no longer than 1 or 2 weeks. If your sleep problems continue, consult your doctor, who will determine whether other measures are needed to overcome your sleep problems.

Dependence: Sleep medicines can cause dependence, especially when these medicines are used regularly for longer than a few weeks or at high doses. Some people develop a need to continue taking their medicines. This is known as dependence or "addiction."

When people develop dependence, they may have difficulty stopping the sleep medicine. If the medicine is suddenly stopped, the body is not able to function normally and unpleasant symptoms may occur (see *Withdrawal*). They may find that they have to keep taking the medicines either at the prescribed dose or at increasing doses just to avoid withdrawal symptoms.

All people taking sleep medicines have some risk of becoming dependent on the medicine. However, people who have been dependent on alcohol or other drugs in the past may have a higher chance of becoming addicted to sleep medicines. This possibility must be considered before using these medicines for more than a few weeks.

If you have been addicted to alcohol or drugs in the past, it is important to tell your doctor before starting Ambien CR or any sleep medicine.

Withdrawal: Withdrawal symptoms may occur when sleep medicines are stopped suddenly after being used daily for a long time. In some cases, these symptoms can occur even if the medicine has been used for only a week or two.

In mild cases, withdrawal symptoms may include unpleasant feelings. In more severe cases, abdominal and muscle cramps, vomiting, sweating, shakiness, and rarely, seizures may occur. These more severe withdrawal symptoms are very uncommon.

Another problem that may occur when sleep medicines are stopped is known as "rebound insomnia." This means that a person may have more trouble sleeping the first few nights after the medicine is stopped than before starting the medicine. If you should experience rebound insomnia, do not get discouraged. This problem usually goes away on its own after 1 or 2 nights.

If you have been taking Ambien CR or any other sleep medicine for more than 1 or 2 weeks, do not stop taking it on your own. Always follow your doctor's directions.

Changes in behavior and thinking: Some people using sleep medicines have experienced unusual changes in their thinking and/or behavior. These effects are not common. However, they have included:

- more outgoing or aggressive behavior than normal
- confusion
- strange behavior
- agitation
- hallucinations
- worsening of depression
- suicidal thoughts

How often these effects occur depends on several factors, such as a person's general health, the use of other medicines, and which sleep medicine is being used.

It is also important to realize that it is rarely clear whether these behavior changes are caused by the medicine, an illness, or occur on their own. In fact, sleep problems that do not improve may be due to illnesses that were present before the medicine was used. If you or your family notice any changes in your behavior, or if you have any unusual or disturbing thoughts, call your doctor immediately.

Pregnancy: Sleep medicines may cause sedation of the unborn baby when used during the last weeks of pregnancy.

Be sure to tell your doctor if you are pregnant, if you are planning to become pregnant, or if you become pregnant while taking Ambien CR.

SAFE USE OF SLEEPING MEDICINES

To ensure the safe and effective use of Ambien CR or any other sleep medicine, you should observe the following cautions:

1. Ambien CR is a prescription medicine and should be used ONLY as directed by your doctor. Follow your doctor's instructions about how to take, when to take, and how long to take Ambien CR. Ambien CR tablets should not be divided, crushed, or chewed, and must be swallowed whole.
2. Never use Ambien CR or any other sleep medicine for longer than directed by your doctor.
3. If you develop an allergic reaction such as rash, hives, shortness of breath or swelling of your tongue or throat when using Ambien CR or any other sleep medicine, discontinue Ambien CR or other sleep medicine immediately and contact your doctor.
4. If you notice any unusual and/or disturbing thoughts or behavior during treatment with Ambien CR or any other sleep medicine, contact your doctor.
5. Tell your doctor about any medicines you may be taking, including medicines you may buy without a prescription. You should also tell your doctor if you drink alcohol. DO NOT use alcohol while taking Ambien CR or any other sleep medicine.
6. Do not take Ambien CR unless you are able to get a full night's sleep before you must be active again. For example, Ambien CR should not be taken on an overnight airplane flight of less than 7 to 8 hours since "traveler's amnesia" may occur.
7. Do not increase the prescribed dose of Ambien CR or any other sleep medicine unless instructed by your doctor.
8. When you first start taking Ambien CR or any other sleep medicine, until you know whether the medicine will still have some carryover effect in you the next day, use extreme care while doing anything that requires complete alertness, such as driving a car, operating machinery, or piloting an aircraft.
9. Be aware that you may have more sleeping problems the first night after stopping Ambien CR or any other sleep medicine.
10. Be sure to tell your doctor if you are pregnant, if you are planning to become pregnant, or if you become pregnant while taking Ambien CR or any other sleep medicine.
11. As with all prescription medicines, never share Ambien CR or any other sleep medicine with anyone else. Always store Ambien CR or any other sleep medicine in the original container that you received it in and store it out of reach of children.
12. Ambien CR works very quickly. You should only take Ambien CR right before going to bed and are ready to go to sleep.

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Long before the Lincoln Cent was introduced in 1909, before the electric light and the automobile, the Indian Head Cent was the coin of America's pioneer era. These are the coins used by soldiers during the Civil War and prospectors exploring the Wild West. They witnessed General George Custer's last stand at the Little Big Horn and the Wright Brothers first flight at Kitty Hawk. Today, Indian Head Cents are genuine pieces of history that you can hold in your hands — if you can find them! Rarely seen today except in private collections, most all were lost or melted down ages ago. Today in a single year the U.S. government makes **FOUR TIMES** as many Lincoln Cents as ALL the Indian Head Cents made in their entire era of 1864-1909!

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A cradle on the gate of an Italian convent gives desperate mothers a safe place to abandon a baby.

Full Circle The idea behind an Italian convent's newfangled box for abandoned babies is as old as the 12th century. In 1198, deploring the number of dead infants found floating in the Tiber, Pope Innocent III ordered convents to install foundling wheels—revolving compartments to deliver babies anonymously into the care of nuns. Similarly, the box welded onto the gate of Bergamo's Matris Domini Convent in February (above) opens to an insulated cradle. An alarm sounds when a child is placed inside; the sisters call nearby Riuniti Hospital, which picks up the baby within minutes. Foundling wheels fell out of use by the mid-1900s. Germany introduced a latter-day version in 2000 and now has some 80. In Hamburg alone, 38 infants have been left in the city's two "baby hatches." In 2006, Italy revived the tradition, hoping to help unwed mothers—often illegal immigrants afraid of the authorities. Says Riuniti's Dr. Regina Barbo: "Their suffering and fear is as great today as ever." *—Karen E. Lange*

PHOTO: GIANLUCA COLLA



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CANINE TABOOS

Seemingly innocuous foods can be risky for a dog, depending on its size and how much is eaten.



Alcohol

It depresses brain function and can cause a coma. So no piña coladas for Fido—not for fun and not by accident with party leftovers.

Chocolate

The chemical theobromine can be fatal. Just three ounces of dark or seven of milk can bring on vomiting in a 50-pound dog.

Garlic

Garlic breaks down a dog's red blood cells, leading to anemia and possible kidney failure from leaking hemoglobin.

Grapes

Toxicologists have found that grapes and raisins can cause renal failure. They're still trying to learn why.

Coffee

The caffeine in a cup of java is a methylxanthine compound that can increase a dog's heart rate and trigger seizures.

Macadamia nuts

Experts have yet to determine why just a few of these nuts can produce tremors, even temporary paralysis, in a dog's hind legs.

Onions

Their damage to canine hemoglobin is cumulative, so small tastes over time can be worse than wolfing down the whole bulb.

Spotting Pet Threats This year, pet food contaminated with melamine caused kidney failure and other problems in cats and dogs. Ordinary human foods can also be dangerous to dogs, and the list of potentially hazardous items is growing. Reports from pet owners can prompt an investigation, says Eric Dunayer, senior toxicologist at the ASPCA's Animal Poison Control Center in Urbana, Illinois. In 2006, the center's hotline fielded roughly 116,000 calls. Nearly 200 asked about xylitol, a sugar substitute gaining popularity in baked goods, candy, and gum. "We often see vomiting, followed by weakness, staggering, collapse, and possibly seizures as blood sugar drops," says Dunayer. For tiny breeds like five-pound miniature dachshund Marcel (above), even a wee dose could be perilous. *—Catherine L. Barker*

PHOTOS: NATIONAL GEOGRAPHIC PHOTOGRAPHER MARK THIESSEN

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48 miles per kernel.

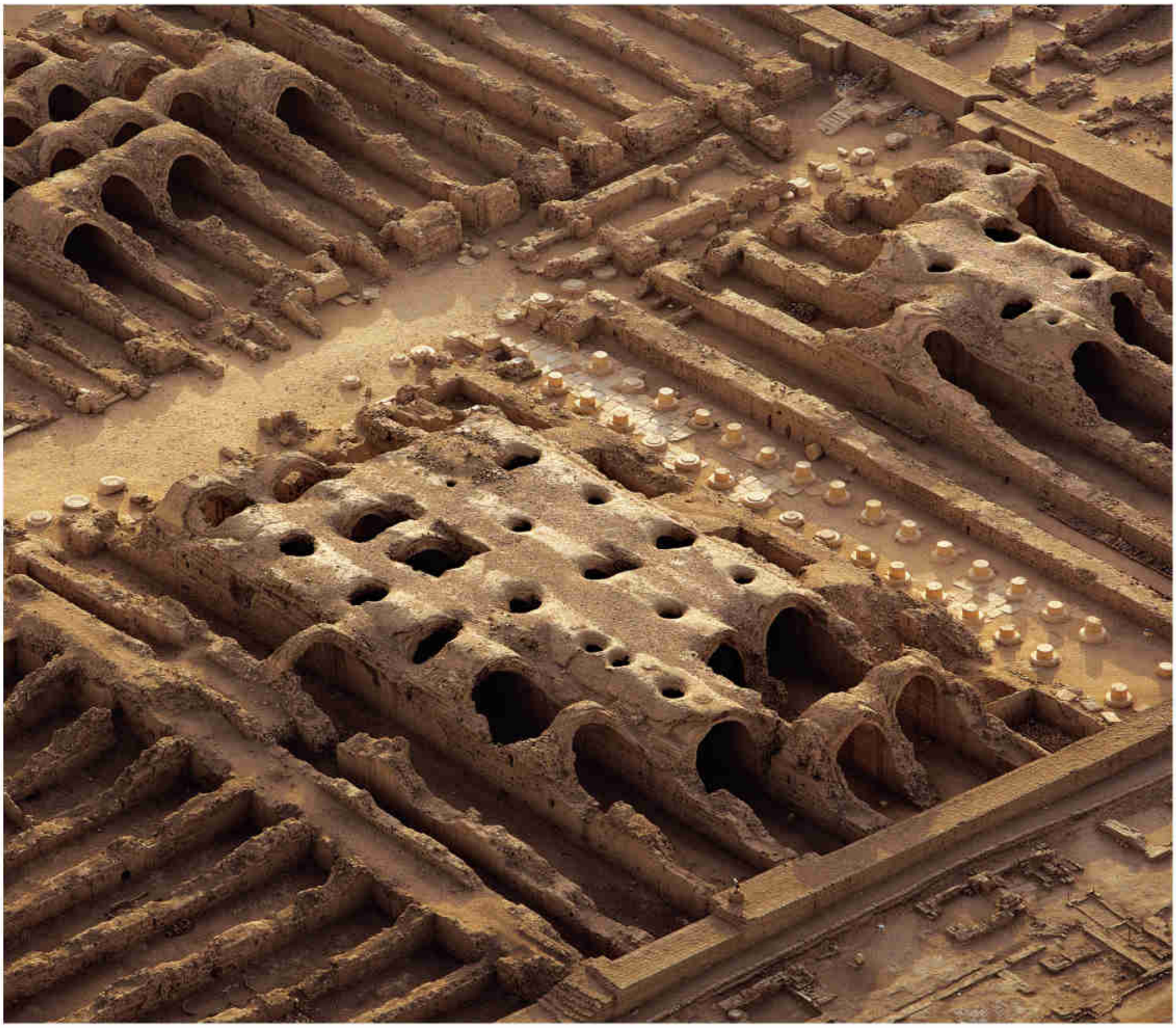
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WHERE IN THE WORLD?



Ancient Egyptians loaded grain into mud-brick storehouses through the openings in the buildings' roofs—now further honeycombed by time and wear.

Dying City of the Dead Vaulted storehouses still stand within the walls of Egypt's Ramesseum, the royal mortuary temple complex built by Ramses II in the 13th century B.C. The mud-brick buildings once held grain and other supplies for priests of the pharaoh's mortuary cult. Though situated in low desert at the edge of the floodplain, the Ramesseum—like other ancient sites at Karnak and Luxor, just across the Nile—is more threatened by rising groundwater than floods. Irrigation of nearby sugarcane crops and inadequate local sewage systems have boosted area groundwater levels and increased its salinity. The porous stone monuments are wicking the rising water, then crumbling as the salt crystallizes within them. A site management plan at Luxor is already helping reduce groundwater levels there. "If something isn't done soon," notes Zahi Hawass, chief of Egypt's Supreme Council of Antiquities, "the ruins will disappear in the next century, after having survived thousands of years." *—Margaret G. Zackowitz*

PHOTO: MICHAEL POLIZA

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Protecting the planet
has become a rallying cry
for all Americans.

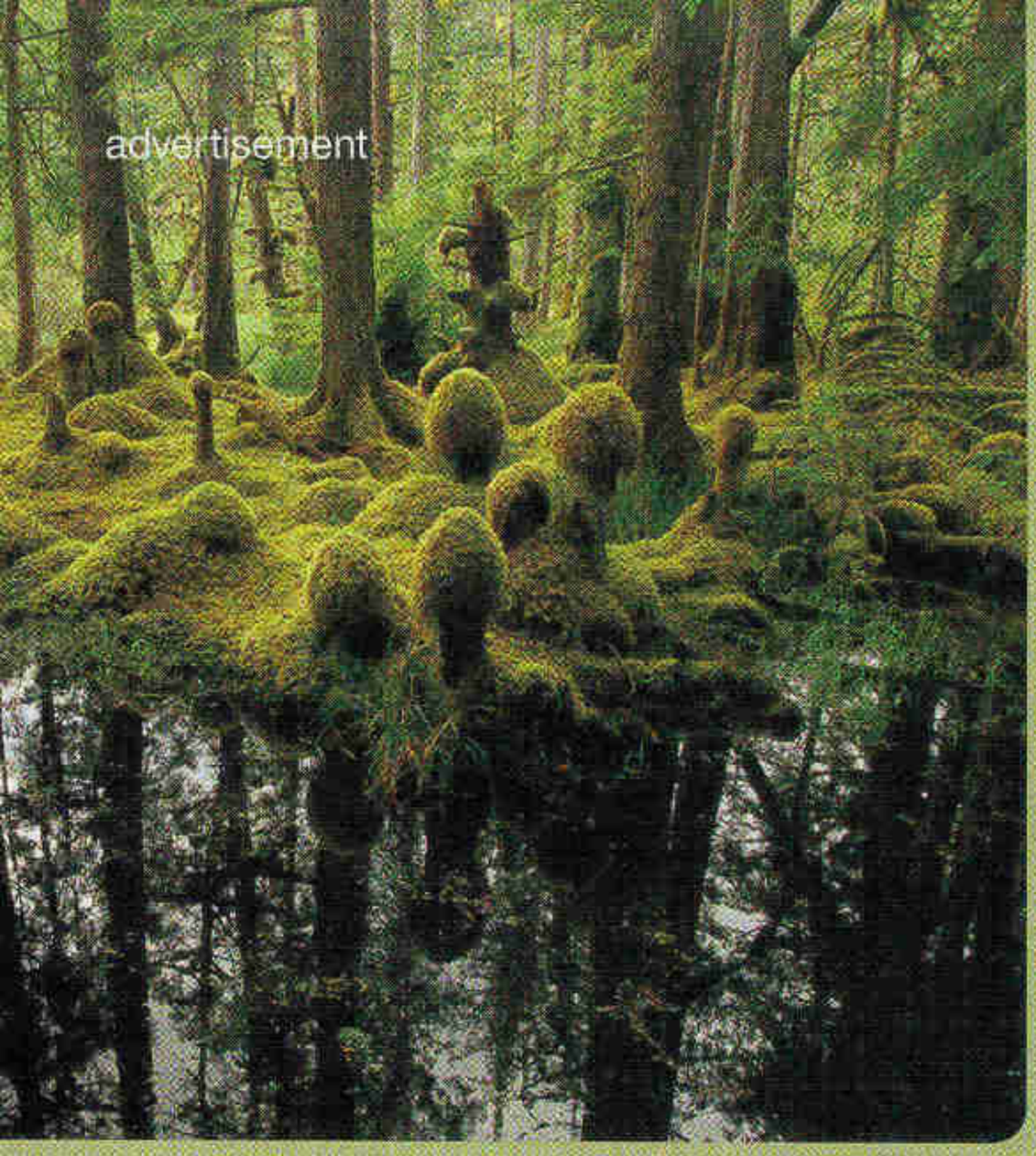
GLOBAL
Climate Change CHAMPIONS

Learn how two government programs have inspired private corporations
to set new standards in the quest for environmental leadership.

CLIMATE LEADERS
U.S. Environmental Protection Agency

ENERGY STAR

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Concern for global warming has truly escalated over the past decade. Climate change affects agriculture, the availability of clean water, the intensity of storms, as well as rising sea temperatures and sea levels.

In February 2002, the U.S. Environmental Protection Agency (EPA) launched the Climate Leaders program in an effort to reduce greenhouse gas (GHG) emissions and the risks associated with global warming. This program partners with companies to devise long-term climate change strategies by setting aggressive goals over the next five to ten years.

Through the program, the EPA provides technical support to partners to help them measure the emissions sources of six major gases using the Climate Leaders GHG inventory protocol. Through the careful tracking and reduction of these emissions, corporations are meeting their environmental goals.

By reaping the benefits of eco-responsible behavior, these companies have also improved their overall business models.

Since each corporation is unique, the mitigation of their respective climate footprints can be varied. The Climate Leaders program uses a customized approach for reaching emissions reduction goals, with companies finding opportunities in onsite energy use and waste disposal, air conditioning/refrigeration, purchased electricity, mobile sources, and other areas.

By reaping the benefits of eco-responsible behavior, these companies have also improved their overall business models. In fact, in the past five years, the business partners of Climate Leaders have grown from 11 to nearly 150, representing a variety of industries from heavy manufacturing and finance to health care and packaged goods. And these companies aren't just giving us lip service: The first eight have already achieved their goals.

Learn more about the Climate Leaders program and partners at *epa.gov/climateleaders*.

Going After GLOBAL WARMING

Unilever

At Unilever, corporate responsibility and sustainable development are central to our business strategy and Vitality mission. Unilever's commitment to sustainability challenges us to find innovative ways to maximize business and brand value while minimizing our environmental footprint.

Eco-efficient production, sustainable sourcing, responsible product design, and brand innovation are key to delivering on our growth strategy. We believe that successful brands of the future will be those that not only provide functional benefits, but also meet the concerns of consumers as citizens; in other words, brands that not only make you feel good, look good, and get more out of life, but that also do good.

Working with the EPA and others who share our vision and commitment to responsibly reducing environmental impacts will provide us with the opportunity to reconfirm our long-term approach and continue to work for a more sustainable future.



Unilever's mission is to add Vitality to Life. We meet everyday needs for nutrition, hygiene, and personal care with brands that help people feel good, look good, and get more out of life.

Tackling environmental, social, and economic issues not only makes good business sense, it is our responsibility.

We have a long-standing commitment to reducing greenhouse gas emissions. Over the past decade, we have reduced CO_2 emissions by more than 30% in our own manufacturing operations. Last year alone, we decreased CO_2 emissions by 4.2%.

As a result of our actions, the Carbon Disclosure Project has ranked Unilever #1 in the food and retail sector's Climate Leadership Index 2006 for having the most comprehensive climate-change disclosure practices.

While we continue to make progress, we believe more can be done. That's why we are collaborating with partners and interested stakeholders to be part of the solution in addressing the issues associated with climate change.

Working together, we believe we can do well by doing good.

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Save energy. Save expenses. Save the environment. That's the mission of the EPA's ENERGY STAR program.

Started by the EPA in 1992, the ENERGY STAR program helps consumers and businesses save energy, save money, and fight global warming. Today more than 50 different kinds of products, as well as new homes and commercial and industrial buildings, can earn the ENERGY STAR label.

In order to earn the ENERGY STAR label, a product, new home, or building must meet the EPA's highest standards of energy efficiency.

This widely recognized seal of approval is an immediate source of technical information to help businesses and consumers best choose energy-efficient solutions. The program has partnered with more than 9,000 private and public organizations, and as many as 35,000 product models bear the ENERGY STAR label—from laptops and water coolers to air conditioners and lightbulbs.

In 2006, Americans—with the help of ENERGY STAR—saved 14 billion dollars on utility bills and reduced greenhouse gas emissions equivalent to those from 25 million cars!

Seek to Save

Many people may not realize that the average home is responsible for twice the greenhouse gas emissions of the average car. So the choices we make at home directly impact the quality of our environment. Energy-efficient products help save energy without sacrificing features, style, or performance. Simple strategies can help a family save up to one-third on their energy bill. Here is how you can get started:

- *When purchasing new household products, choose those that have earned the ENERGY STAR label, as they meet the strict energy-efficiency guidelines set by the EPA and U.S. Department of Energy. To find qualified products, visit* energystar.gov *and click on Products.*
- *If seeking a new home, go green by looking for newer construction that has earned the ENERGY STAR label. These homes will have more effective insulation, high-performance windows, and efficient heating and cooling systems. To learn more, visit* energystar.gov *and click on New Homes.*
- *When remodeling, get recommendations for energy-saving home improvements at* energystar.gov *in the Home Improvement section. You can even use the ENERGY STAR Home Energy Yardstick to compare your home's energy efficiency to similar homes across the country.*
- *For energy-saving advice for the entire family, go to* energystar.gov/home *to explore a virtual home room-by-room and learn easy energy saving tips for everyday living.*

Carrier®

Turn to the Experts.℠

Every three seconds Carrier Corp., a leader in heating, air conditioning, and refrigeration systems, ships out a product. Its eco-friendly philosophy is just as consistent. Says John Mandyck, Carrier's V.P. of Government and International Relations, "We can't offer a green product unless it's produced in a green manner."

Mandyck continued, "We took early action to sustain the environment. Chlorine-containing refrigerants like CFCs can damage the Earth's ozone layer, and in 1994, Carrier was the first company in its industry to phase out CFC chemicals from our products—two years ahead of the United States' requirements (and 16 years ahead of developing countries worldwide). In 1996 Carrier was also first to introduce a total non-ozone depleting system for commercial use, as well as Puron, a non-ozone depleting system for residential use. We're also pleased to say that since 1997 we've doubled our sales while holding our energy use flat.

"We're very proud of our successes. In fact, we worked with National Geographic headquarters to replace their old CFC chillers with energy-efficient chillers that use an ozone-friendly HFC-based refrigerant. The improvement has been substantial. The Global Warming Potential of the refrigerant (a measurement of how much a given greenhouse gas contributes to global warming) dropped over 80%. Plus, energy usage is now 30% more efficient for cooling."

When asked if Carrier Corp. had any new environmental goals to share, Mandyck said, "We take our environmental stance seriously, and our parent company, United Technologies Corporation, is a proud partner of the EPA's Climate Leaders program. Corporate-wide, our new goal is to reduce GHG emissions on an absolute basis by 3% per year."

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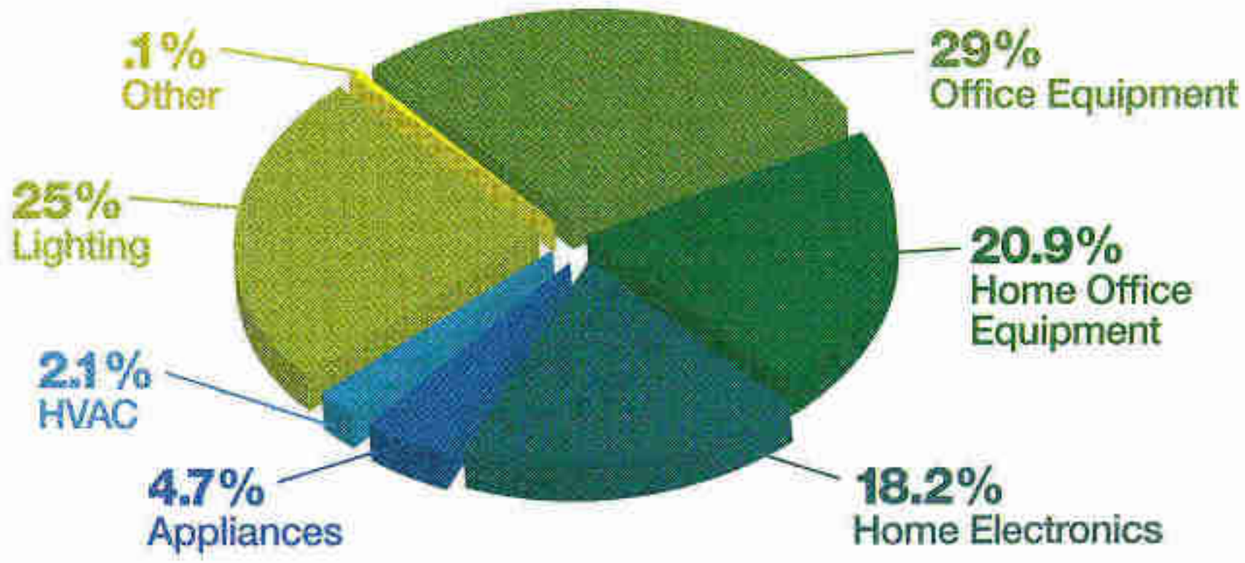
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A Hybrid Heat™ System is comprised of a Carrier heat pump, gas furnace and a compatible thermostat control. Heating cost savings as compared to Carrier BASE model gas furnace. ©CARRIER CORPORATION 2007. A member of the United Technologies Corporation family. Stock symbol UTX.

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More than two billion ENERGY STAR qualified products have been purchased since 1992 (see the variety in the chart below). Consider ENERGY STAR qualified products and practices to help you save money, be comfortable in your home, and do your part to reduce greenhouse gas emissions. It will help your family now… and in the future. Learn more at *energystar.gov*.



DID*you*KNOW?

The U.S. accounts for 5% of the world's population, but is responsible for about 20% of the global greenhouse gas emissions.

Source: U.S. Environmental Protection Agency

Energy production and use account for nearly 88% of greenhouse gas emissions and more environmental damage than any other human activity.

Source: The Alliance to Save Energy

Global Climate Change Champions

Join these partners who are making significant achievements to reduce their greenhouse gas emissions and carbon footprint.

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Lockheed Martin pledges to reduce U.S. GHG emissions by 30 percent per dollar revenue from 2001 to 2010.

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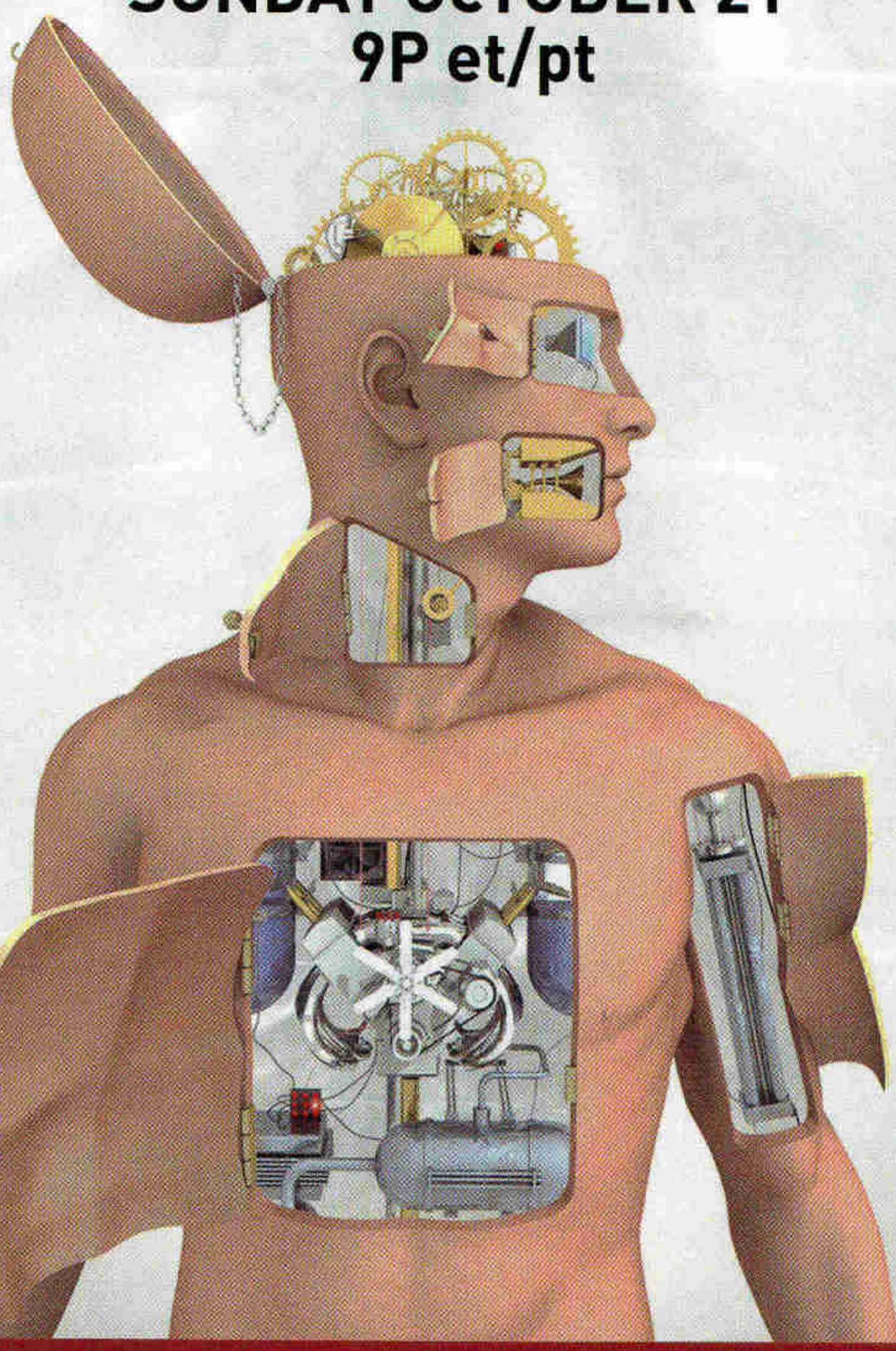
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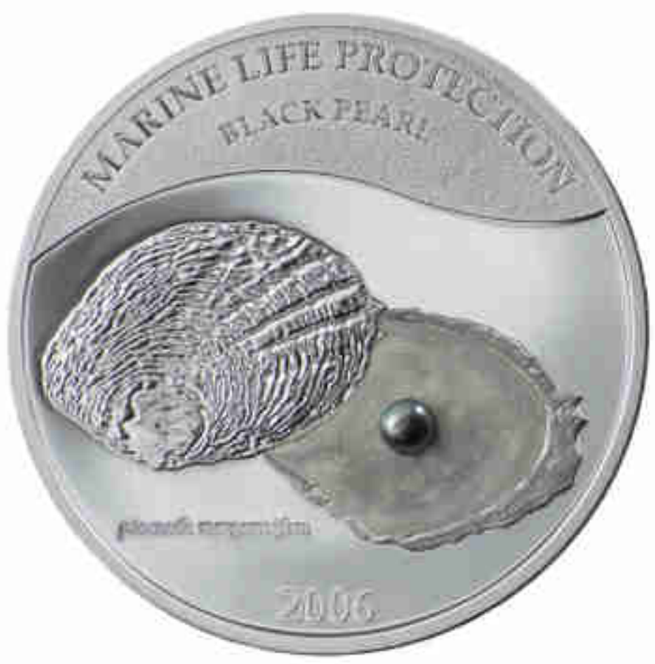
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Palau: water from Lourdes, France



Niue Island: an LED bulb that lights up



Palau: a genuine pearl



Liberia: coal from the *Titanic*



Palau: a four-leaf clover



Palau: volcanic rock from the island



Poland: an amber soccer ball

In the Money Pardon me, is that a meteorite in your coin? Actually, yes! A growing number of countries are embedding objects in commemoratives. That's how space debris from China ended up in a coin from Palau. Numismatists scoff, but lovers of curios are hooked. A typical mintage is 1,000 to 10,000 coins, priced $50 to $100 for silver, about $1,000 for gold. The result can be a boon for national coffers. Canada and Poland are among the nations minting the coins themselves. Other times, a private issuer like Liechtenstein's Coin Invest Trust pays a licensing fee. Embedding techniques include covering the object with acrylic or using adhesive. For the water from Lourdes (above), a hole was cut, a vial inserted and sealed. New twists abound. A rectangular van Gogh coin has crystals and colorized versions of "Starry Night" and "Sunflowers." Another issue plays JFK saying, *"Ich bin ein Berliner."* Definitely not pocket change. *—Carl Harrington*

PHOTOS: NATIONAL GEOGRAPHIC PHOTOGRAPHER MARK THIESSEN

Dad wiL U Lt me tak ur nu car 4 a spn

Sometimes it seems like your teen speaks a different language.
Which makes it pretty tough when you need to talk to them about certain issues, like smart driving. But we've created a Web site with the help of the National Safety Council to make "the talk" a little easier. At nationwidesmartride.com, we've included tips and tools to help you make your teen a smarter driver. You'll even find expert research from psychologists focused on teen brain development and ways to effectively communicate with them. Even understand them. So no lectures, eye rolling or whatevers. Just you and your teen talking face to face about smart driving. Now that's Life Comes at You Fast® or, as they'd say, LCAYF.

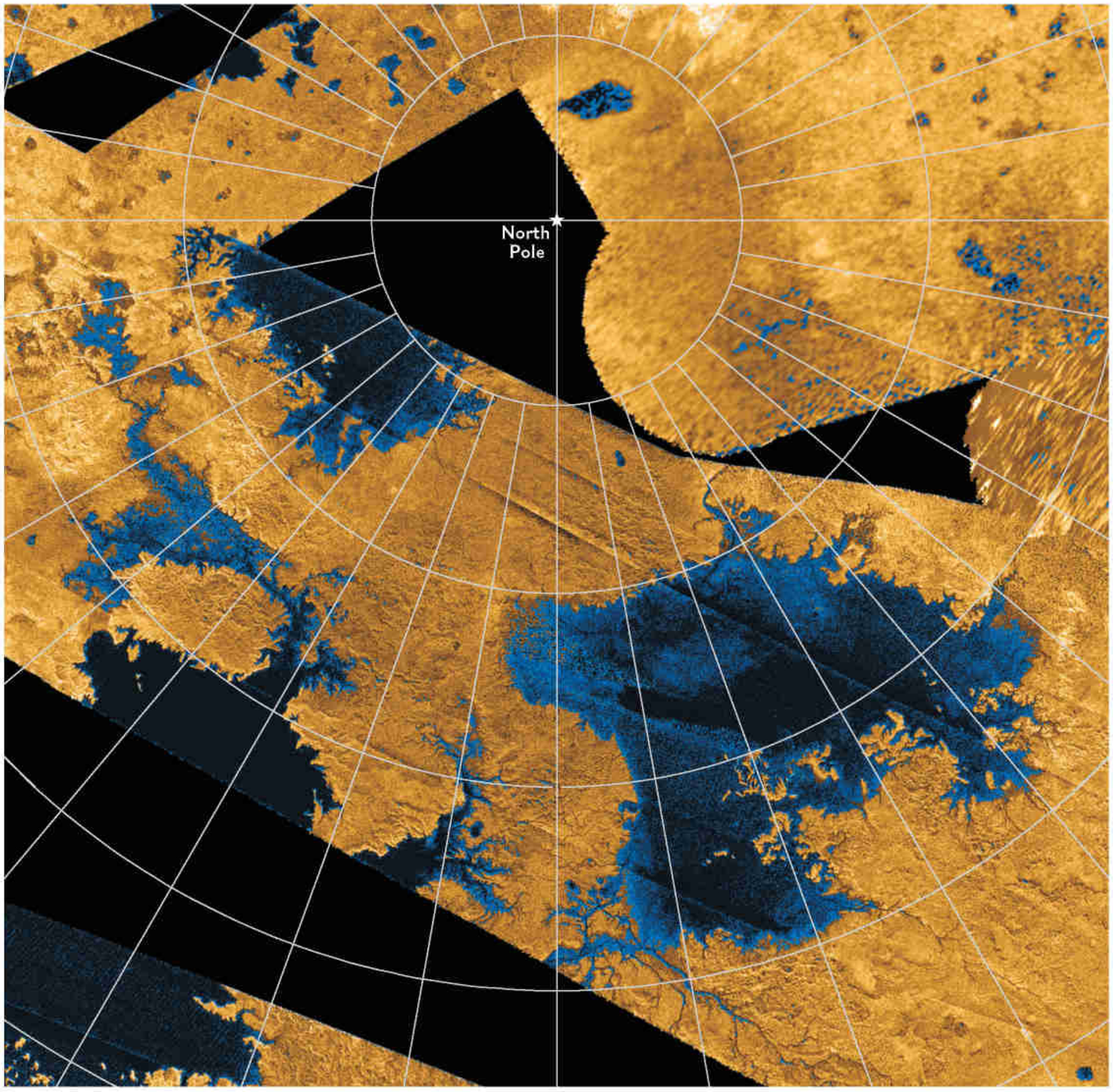
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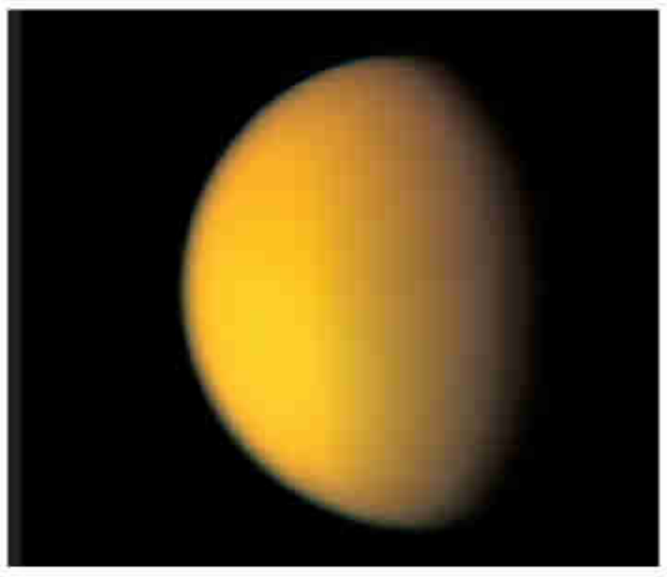
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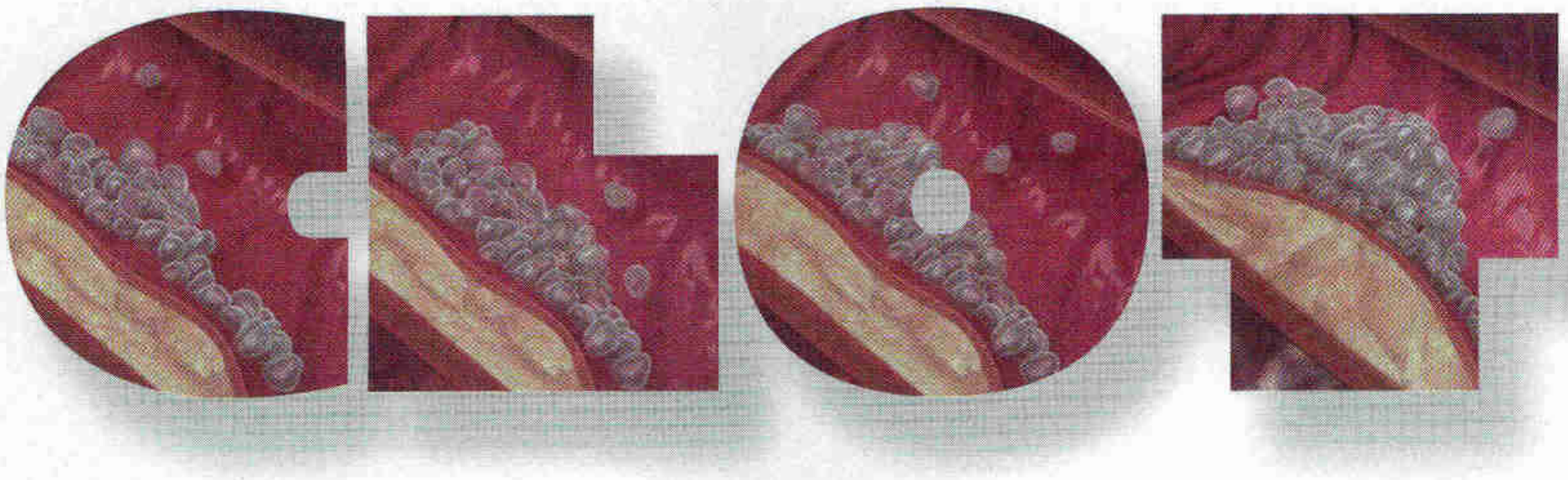


Titanic Lakes If you think Earth is the only sphere in the solar system with lakes, you're all wet. Flying over Titan's northern polar region last year, the Cassini orbiter found that the largest of Saturn's many moons has more than a hundred bodies of liquid, some larger than America's Great Lakes and a few big enough to be deemed seas. Fed by rocky, muddy streams, they look pretty much like earthly lakes, says Titan expert Jonathan Lunine of the University of Arizona. But a space tourist wouldn't want to take a dip. With Titan's temperature at minus 290°F, the lakes are filled with frigid liquid methane and ethane. Evaporating liquid probably plays a role in replenishing methane in the thick atmosphere. Cassini will now look for lakes at the moon's southern pole. *—Bill Douthitt*



Saturn's moon Titan (above) has more than 100 lakes (colorized blue in the image at top).

RADAR IMAGE (TOP): CASSINI IMAGING TEAM, NASA/JPL/SPACE SCIENCE INSTITUTE. COMPOSITE IMAGE (ABOVE): NASA/JPL

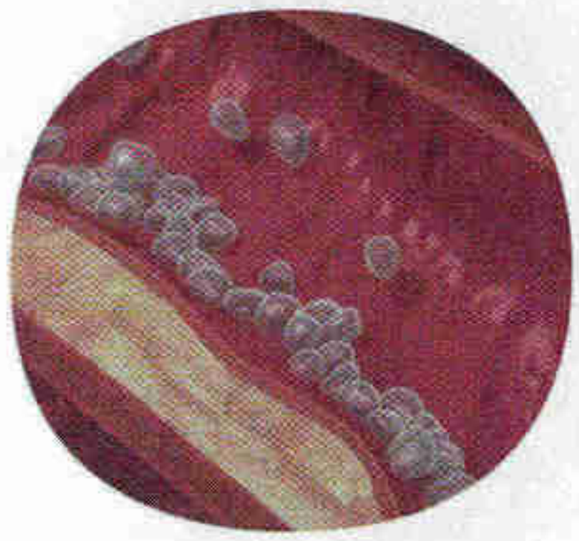


You can help protect against the formation of clots and reduce your risk of a future heart attack or stroke.

This is important information if you've been hospitalized with heart-related chest pain or a certain type of heart attack. That's because these conditions, known as Acute Coronary Syndrome—or ACS—are usually caused when blood platelets stick together and form clots that block blood flow to your heart. And if you've already had a clot, you're at an increased risk for a future heart attack or stroke.

PLAVIX, taken with other heart medicines, helps provide greater protection against heart attack or stroke than other heart medicines alone.

That's because prescription PLAVIX works differently than your cholesterol and blood pressure medications, focusing on your blood platelets to help keep them from sticking together and forming clots.



IMPORTANT INFORMATION: If you have a stomach ulcer or other condition that causes bleeding, you should not use PLAVIX. When taking PLAVIX alone or with some medicines including aspirin, the risk of bleeding may increase. To minimize this risk, always talk to your doctor before taking aspirin or other medicines with PLAVIX, especially if you've had a stroke. Additional rare but serious side effects could occur.

See important product information on the following pages.

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PLAVIX®

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INDICATIONS AND USAGE

PLAVIX (clopidogrel bisulfate) is indicated for the reduction of atherothrombotic events as follows:

- **Recent MI, Recent Stroke or Established Peripheral Arterial Disease**

 For patients with a history of recent myocardial infarction (MI), recent stroke, or established peripheral arterial disease, PLAVIX has been shown to reduce the rate of a combined endpoint of new ischemic stroke (fatal or not), new MI (fatal or not), and other vascular death.

- **Acute Coronary Syndrome**

 -For patients with non-ST-segment elevation acute coronary syndrome (unstable angina/ non-Q-wave MI) including patients who are to be managed medically and those who are to be managed with percutaneous coronary intervention (with or without stent) or CABG, PLAVIX has been shown to decrease the rate of a combined endpoint of cardiovascular death, MI, or stroke as well as the rate of a combined endpoint of cardiovascular death, MI, stroke, or refractory ischemia

 -For patients with ST-segment elevation acute myocardial infarction, PLAVIX has been shown to reduce the rate of death from any cause and the rate of a combined endpoint of death, re-infarction or stroke. This benefit is not known to pertain to patients who receive primary angioplasty.

CONTRAINDICATIONS

The use of PLAVIX is contraindicated in the following conditions:

Hypersensitivity to the drug substance or any component of the product.

Active pathological bleeding such as peptic ulcer or intracranial hemorrhage.

WARNINGS

Thrombotic thrombocytopenic purpura (TTP):

TTP has been reported rarely following use of PLAVIX, sometimes after a short exposure (<2 weeks). TTP is a serious condition that can be fatal and requires urgent treatment including plasmapheresis (plasma exchange). It is characterized by thrombocytopenia, microangiopathic hemolytic anemia (schistocytes [fragmented RBCs] seen on peripheral smear), neurological findings, renal dysfunction, and fever. (See **ADVERSE REACTIONS**.)

PRECAUTIONS

General

PLAVIX prolongs the bleeding time and therefore should be used with caution in patients who may be at risk of increased bleeding from trauma, surgery, or other pathological conditions (particularly gastrointestinal and intraocular). If a patient is to undergo elective surgery and an antiplatelet effect is not desired, PLAVIX should be discontinued 5 days prior to surgery.

Due to the risk of bleeding and undesirable hematological effects, blood cell count determination and/or other appropriate testing should be promptly considered, whenever such suspected clinical symptoms arise during the course of treatment (see **ADVERSE REACTIONS**).

In patients with recent TIA or stroke who are at high risk for recurrent ischemic events, the combination of aspirin and PLAVIX has not been shown to be more effective than PLAVIX alone, but the combination has been shown to increase major bleeding.

GI Bleeding: In CAPRIE, PLAVIX was associated with a rate of gastrointestinal bleeding of 2.0%, vs. 2.7% on aspirin. In CURE, the incidence of major gastrointestinal bleeding was 1.3% vs 0.7% (PLAVIX + aspirin vs. placebo + aspirin, respectively). PLAVIX should be used with caution in patients who have lesions with a propensity to bleed (such as ulcers). Drugs that might induce such lesions should be used with caution in patients taking PLAVIX.

Use in Hepatically Impaired Patients: Experience is limited in patients with severe hepatic disease, who may have bleeding diatheses. PLAVIX should be used with caution in this population.

Use in Renally-impaired Patients: Experience is limited in patients with severe renal impairment. PLAVIX should be used with caution in this population.

Information for Patients

Patients should be told it may take them longer than usual to stop bleeding, that they may bruise and/or bleed more easily when they take PLAVIX or PLAVIX combined with aspirin, and that they should report any unusual bleeding to their physician. Patients should inform physicians and dentists that they are taking PLAVIX and/or any other product known to affect bleeding before any surgery is scheduled and before any new drug is taken.

Drug Interactions

Study of specific drug interactions yielded the following results:

Aspirin: Aspirin did not modify the clopidogrel-mediated inhibition of ADP-induced platelet aggregation. Concomitant administration of 500 mg of aspirin twice a day for 1 day did not significantly increase the prolongation of bleeding time induced by PLAVIX. PLAVIX potentiated the effect of aspirin on collagen-induced platelet aggregation. PLAVIX and aspirin have been administered together for up to one year.

Heparin: In a study in healthy volunteers, PLAVIX did not necessitate modification of the heparin dose or alter the effect of heparin on coagulation. Coadministration of heparin had no effect on inhibition of platelet aggregation induced by PLAVIX.

Nonsteroidal Anti-Inflammatory Drugs (NSAIDs): In healthy volunteers receiving naproxen, concomitant administration of PLAVIX was associated with increased occult gastrointestinal blood loss. NSAIDs and PLAVIX should be coadministered with caution.

Warfarin: Because of the increased risk of bleeding, the concomitant administration of warfarin with PLAVIX should be undertaken with caution. (See **PRECAUTIONS– General.**)

Other Concomitant Therapy: No clinically significant pharmacodynamic interactions were observed when PLAVIX was coadministered with **atenolol, nifedipine,** or both atenolol and nifedipine. The pharmacodynamic activity of PLAVIX was also not significantly influenced by the coadministration of **phenobarbital, cimetidine** or **estrogen.**

The pharmacokinetics of **digoxin** or **theophylline** were not modified by the coadministration of PLAVIX (clopidogrel bisulfate).

At high concentrations *in vitro*, clopidogrel inhibits P_{450} (2C9). Accordingly, PLAVIX may interfere with the metabolism of **phenytoin, tamoxifen, tolbutamide, warfarin, torsemide, fluvastatin,** and many **non-steroidal anti-inflammatory agents,** but there are no data with which to predict the magnitude of these interactions. Caution should be used when any of these drugs is coadministered with PLAVIX.

In addition to the above specific interaction studies, patients entered into clinical trials with PLAVIX received a variety of concomitant medications including **diuretics, beta-blocking agents, angiotensin converting enzyme inhibitors, calcium antagonists, cholesterol lowering agents, coronary vasodilators, antidiabetic agents** (including **insulin**), **thrombolytics, heparins** (unfractionated and LMWH) **GPIIb/IIIa antagonists, antiepileptic agents** and **hormone replacement therapy** without evidence of clinically significant adverse interactions.

There are no data on the concomitant use of oral anticoagulants, non-study oral anti-platelet drugs and chronic NSAIDs with clopidogrel.

Drug/Laboratory Test Interactions

None known.

Carcinogenesis, Mutagenesis, Impairment of Fertility

There was no evidence of tumorigenicity when clopidogrel was administered for 78 weeks to mice and 104 weeks to rats at dosages up to 77 mg/kg per day, which afforded plasma exposures >25 times that in humans at the recommended daily dose of 75 mg.

Clopidogrel was not genotoxic in four *in vitro* tests (Ames test, DNA-repair test in rat hepatocytes, gene mutation assay in Chinese hamster fibroblasts, and metaphase chromosome analysis of human lymphocytes) and in one *in vivo* test (micronucleus test by oral route in mice).

Clopidogrel was found to have no effect on fertility of male and female rats at oral doses up to 400 mg/kg per day (52 times the recommended human dose on a mg/m^2 basis).

Pregnancy

Pregnancy Category B. Reproduction studies performed in rats and rabbits at doses up to 500 and 300 mg/kg/day (respectively, 65 and 78 times the recommended daily human dose on a mg/m^2 basis), revealed no evidence of impaired fertility or fetotoxicity due to clopidogrel. There are, however, no adequate and well-controlled studies in pregnant women. Because animal reproduction studies are not always predictive of a human response, PLAVIX should be used during pregnancy only if clearly needed.

Nursing Mothers

Studies in rats have shown that clopidogrel and/or its metabolites are excreted in the milk. It is not known whether this drug is excreted in human milk. Because many drugs are excreted in human milk and because of the potential for serious adverse reactions in nursing infants, a decision should be made whether to discontinue nursing or to discontinue the drug, taking into account the importance of the drug to the nursing woman.

Pediatric Use

Safety and effectiveness in the pediatric population have not been established.

Geriatric Use

Of the total number of subjects in CAPRIE, CURE and CLARITY controlled clinical studies, approximately 50% of patients treated with PLAVIX were 65 years of age and older and 15% were 75 years and older. In COMMIT, approximately 58% of the patients treated with PLAVIX were 60 years and older, 26% of whom were 70 years and older.

The observed risk of thrombotic events with clopidogrel plus aspirin versus placebo plus aspirin by age category is provided in Figures 3 and 6 for the CURE and COMMIT trials, respectively (see **CLINICAL STUDIES**). The observed risk of bleeding events with clopidogrel plus aspirin versus placebo plus aspirin by age category is provided in Tables 5 and 6 for the CURE and COMMIT trials, respectively (see **ADVERSE REACTIONS**).

ADVERSE REACTIONS

PLAVIX has been evaluated for safety in more than 42,000 patients, including over 9,000 patients treated for 1 year or more. The clinically important adverse events observed in CAPRIE, CURE, CLARITY and COMMIT are discussed below.

The overall tolerability of PLAVIX in CAPRIE was similar to that of aspirin regardless of age, gender and race, with an approximately equal incidence (13%) of patients withdrawing from treatment because of adverse reactions.

Hemorrhagic: In CAPRIE patients receiving PLAVIX, gastrointestinal hemorrhage occurred at a rate of 2.0%, and required hospitalization in 0.7%. In patients receiving aspirin, the corresponding rates were 2.7% and 1.1%, respectively. The incidence of intracranial hemorrhage was 0.4% for PLAVIX compared to 0.5% for aspirin.

In CURE, PLAVIX use with aspirin was associated with an increase in bleeding compared to placebo with aspirin (see Table 5). There was an excess in major bleeding in patients receiving PLAVIX plus aspirin compared with placebo plus aspirin, primarily gastrointestinal and at puncture sites. The incidence of intracranial hemorrhage (0.1%), and fatal bleeding (0.2%), were the same in both groups.

The overall incidence of bleeding is described in Table 5 for patients receiving both PLAVIX and aspirin in CURE.

Table 5: CURE Incidence of bleeding complications (% patients)

Event	PLAVIX (+ aspirin)* (n=6259)	Placebo (+ aspirin)* (n=6303)	P-value
Major bleeding †	3.7 ‡	2.7 §	0.001
Life-threatening bleeding	2.2	1.8	0.13
Fatal	0.2	0.2	
5 g/dL hemoglobin drop	0.9	0.9	
Requiring surgical intervention	0.7	0.7	
Hemorrhagic strokes	0.1	0.1	
Requiring inotropes	0.5	0.5	
Requiring transfusion (≥4 units)	1.2	1.0	
Other major bleeding	1.6	1.0	0.005
Significantly disabling	0.4	0.3	
Intraocular bleeding with significant loss of vision	0.05	0.03	
Requiring 2-3 units of blood	1.3	0.9	
Minor bleeding ¶	5.1	2.4	<0.001

* Other standard therapies were used as appropriate.

† Life threatening and other major bleeding.

‡ Major bleeding event rate for PLAVIX + aspirin was dose-dependent on aspirin: <100 mg=2.6%; 100-200 mg= 3.5%; >200 mg=4.9%
Major bleeding event rates for PLAVIX + aspirin by age were: <65 years = 2.5%, ≥65 to <75 years = 4.1%, ≥75 years 5.9%

§ Major bleeding event rate for placebo + aspirin was dose-dependent on aspirin: <100 mg=2.0%; 100-200 mg= 2.3%; >200 mg=4.0%
Major bleeding event rates for placebo + aspirin by age were: <65 years = 2.1%, ≥65 to <75 years = 3.1%, ≥75 years 3.6%

¶ Led to interruption of study medication.

Ninety-two percent (92%) of the patients in the CURE study received heparin/LMWH, and the rate of bleeding in these patients was similar to the overall results.

There was no excess in major bleeds within seven days after coronary bypass graft surgery in patients who stopped therapy more than five days prior to surgery (event rate 4.4% PLAVIX + aspirin; 5.3% placebo + aspirin). In patients who remained on therapy within five days of bypass graft surgery, the event rate was 9.6% for PLAVIX + aspirin, and 6.3% for placebo + aspirin.

In CLARITY, the incidence of major bleeding (defined as intracranial bleeding or bleeding associated with a fall in hemoglobin > 5 g/dL) was similar between groups (1.3% versus 1.1% in the PLAVIX + aspirin and in the placebo + aspirin groups, respectively). This was consistent across subgroups of patients defined by baseline characteristics, and type of fibrinolytics or heparin therapy. The incidence of fatal bleeding (0.8% versus 0.6% in the PLAVIX + aspirin and in the placebo + aspirin groups, respectively) and intracranial hemorrhage (0.5% versus 0.7%, respectively) was low and similar in both groups.

The overall rate of noncerebral major bleeding or cerebral bleeding in COMMIT was low and similar in both groups as shown in Table 6 below.

Table 6: Number (%) of Patients with Bleeding Events in COMMIT

Type of bleeding	PLAVIX (+ aspirin) (N = 22961)	Placebo (+ aspirin) (N = 22891)	P-value
Major* noncerebral or cerebral bleeding**	134 (0.6%)	125 (0.5%)	0.59
Major noncerebral	82 (0.4%)	73 (0.3%)	0.48
Fatal	36 (0.2%)	37 (0.2%)	0.90
Hemorrhagic stroke	55 (0.2%)	56 (0.2%)	0.91
Fatal	39 (0.2%)	41 (0.2%)	0.81
Other noncerebral bleeding (non-major)	831 (3.6%)	721 (3.1%)	0.005
Any noncerebral bleeding	896 (3.9%)	777 (3.4%)	0.004

* Major bleeds are cerebral bleeds or non-cerebral bleeds thought to have caused death or that required transfusion.

** The relative rate of major noncerebral or cerebral bleeding was independent of age. Event rates for PLAVIX + aspirin by age were: <60 years = 0.3%, ≥60 to <70 years = 0.7%, ≥70 years 0.8%. Event rates for placebo + aspirin by age were: <60 years = 0.4%, ≥60 to <70 years = 0.6%, ≥70 years 0.7%.

Adverse events occurring in ≥2.5% of patients on PLAVIX in the CAPRIE controlled clinical trial are shown below regardless of relationship to PLAVIX. The median duration of therapy was 20 months, with a maximum of 3 years.

Table 7: Adverse Events Occurring in ≥2.5% of PLAVIX Patients in CAPRIE

	% Incidence (% Discontinuation)	
Body System **Event**	**PLAVIX [n=9599]**	**Aspirin [n=9586]**
Body as a Whole – general disorders		
Chest Pain	8.3 (0.2)	8.3 (0.3)
Accidental/Inflicted Injury	7.9 (0.1)	7.3 (0.1)
Influenza-like symptoms	7.5 (<0.1)	7.0 (<0.1)
Pain	6.4 (0.1)	6.3 (0.1)
Fatigue	3.3 (0.1)	3.4 (0.1)
Cardiovascular disorders, general		
Edema	4.1 (<0.1)	4.5 (<0.1)
Hypertension	4.3 (<0.1)	5.1 (<0.1)
Central & peripheral nervous system disorders		
Headache	7.6 (0.3)	7.2 (0.2)
Dizziness	6.2 (0.2)	6.7 (0.3)
Gastrointestinal system disorders		
Any event	27.1(3.2)	29.8 (4.0)
Abdominal pain	5.6 (0.7)	7.1 (1.0)
Dyspepsia	5.2 (0.6)	6.1 (0.7)
Diarrhea	4.5 (0.4)	3.4 (0.3)
Nausea	3.4 (0.5)	3.8 (0.4)
Metabolic & nutritional disorders		
Hypercholesterolemia	4.0 (0)	4.4 (<0.1)
Musculo-skeletal system disorders		
Arthralgia	6.3 (0.1)	6.2 (0.1)
Back Pain	5.8 (0.1)	5.3 (<0.1)
Platelet, bleeding, & clotting disorders		
Purpura/Bruise	5.3 (0.3)	3.7 (0.1)
Epistaxis	2.9 (0.2)	2.5 (0.1)
Psychiatric disorders		
Depression	3.6 (0.1)	3.9 (0.2)
Respiratory system disorders		
Upper resp tract infection	8.7 (<0.1)	8.3 (<0.1)
Dyspnea	4.5 (0.1)	4.7 (0.1)
Rhinitis	4.2 (0.1)	4.2 (<0.1)
Bronchitis	3.7 (0.1)	3.7 (0)
Coughing	3.1 (<0.1)	2.7(<0.1)
Skin & appendage disorders		
Any event	15.8 (1.5)	13.1 (0.8)
Rash	4.2 (0.5)	3.5 (0.2)
Pruritus	3.3 (0.3)	1.6 (0.1)
Urinary system disorders		
Urinary tract infection	3.1 (0)	3.5 (0.1)

No additional clinically relevant events to those observed in CAPRIE with a frequency ≥2.5%, have been reported during the CURE and CLARITY controlled studies. COMMIT collected only limited safety data.

Other adverse experiences of potential importance occurring in 1% to 2.5% of patients receiving PLAVIX (clopidogrel bisulfate) in the controlled clinical trials are listed below regardless of relationship to PLAVIX. In general, the incidence of these events was similar to that in patients receiving aspirin (in CAPRIE) or placebo + aspirin (in the other clinical trials).

Autonomic Nervous System Disorders: Syncope, Palpitation. *Body as a Whole-general disorders:* Asthenia, Fever, Hernia. *Cardiovascular disorders:* Cardiac failure. *Central and peripheral nervous system disorders:* Cramps legs, Hypoaesthesia, Neuralgia, Paraesthesia, Vertigo. *Gastrointestinal system disorders:* Constipation, Vomiting. *Heart rate and rhythm disorders:* Fibrillation atrial. *Liver and biliary system disorders:* Hepatic enzymes increased. *Metabolic and nutritional disorders:* Gout, hyperuricemia, non-protein nitrogen (NPN) increased. *Musculo-skeletal system disorders:* Arthritis, Arthrosis. *Platelet, bleeding & clotting disorders:* GI hemorrhage, hematoma, platelets decreased. *Psychiatric disorders:* Anxiety, Insomnia. *Red blood cell disorders:* Anemia. *Respiratory system disorders:* Pneumonia, Sinusitis. *Skin and appendage disorders:* Eczema, Skin ulceration. *Urinary system disorders:* Cystitis. *Vision disorders:* Cataract, Conjunctivitis.

Other potentially serious adverse events which may be of clinical interest but were rarely reported (<1%) in patients who received PLAVIX in the controlled clinical trials are listed below regardless of relationship to PLAVIX. In general, the incidence of these events was similar to that in patients receiving aspirin (in the other clinical trials) .

Body as a whole: Allergic reaction, necrosis ischemic. *Cardiovascular disorders:* Edema generalized. *Gastrointestinal system disorders:* Peptic, gastric or duodenal ulcer, gastritis, gastric ulcer perforated, gastritis hemorrhagic, upper GI ulcer hemorrhagic. *Liver and Biliary system disorders:* Bilirubinemia, hepatitis infectious, liver fatty. *Platelet, bleeding and clotting disorders:* hemarthrosis, hematuria, hemoptysis, hemorrhage intracranial, hemorrhage retroperitoneal, hemorrhage of operative wound, ocular hemorrhage, pulmonary hemorrhage, purpura allergic, thrombocytopenia. *Red blood cell disorders:* Anemia aplastic, anemia hypochromic. *Reproductive disorders, female:* Menorrhagia. *Respiratory system disorders:* Hemothorax. *Skin and appendage disorders:* Bullous eruption, rash erythematous, rash maculopapular, urticaria. *Urinary system disorders:* Abnormal renal function, acute renal failure. *White cell and reticuloendothelial system disorders:* Agranulocytosis, granulocytopenia, leukemia, leukopenia, neutropenia.

Postmarketing Experience

The following events have been reported spontaneously from worldwide postmarketing experience:

- *Body as a whole:*
 -hypersensitivity reactions, anaphylactoid reactions, serum sickness
- *Central and Peripheral Nervous System disorders:*
 -confusion, hallucinations, taste disorders
- *Hepato-biliary disorders:*
 -abnormal liver function test, hepatitis (non-infectious), acute liver failure
- *Platelet, Bleeding and Clotting disorders:*
 -cases of bleeding with fatal outcome (especially intracranial, gastrointestinal and retroperitoneal hemorrhage)
 -thrombotic thrombocytopenic purpura (TTP) – some cases with fatal outcome- (see **WARNINGS**).
 -agranulocytosis, aplastic anemia/pancytopenia
 -conjunctival, ocular and retinal bleeding
- *Respiratory, thoracic and mediastinal disorders:*
 -bronchospasm, interstitial pneumonitis
- *Skin and subcutaneous tissue disorders:*
 -angioedema, erythema multiforme, Stevens-Johnson syndrome, toxic epidermal necrolysis, lichen planus
- *Renal and urinary disorders:*
 - glomerulopathy, increased creatinine levels
- *Vascular disorders:*
 - vasculitis, hypotension
- *Gastrointestinal disorders:*
 - colitis (including ulcerative or lymphocytic colitis), pancreatitis, stomatitis
- *Musculoskeletal, connective tissue and bone disorders:*
 - myalgia

OVERDOSAGE

Overdose following clopidogrel administration may lead to prolonged bleeding time and subsequent bleeding complications. A single oral dose of clopidogrel at 1500 or 2000 mg/kg was lethal to mice and to rats and at 3000 mg/kg to baboons. Symptoms of acute toxicity were vomiting (in baboons), prostration, difficult breathing, and gastrointestinal hemorrhage in all species.

Recommendations About Specific Treatment:

Based on biological plausibility, platelet transfusion may be appropriate to reverse the pharmacological effects of PLAVIX if quick reversal is required.

DOSAGE AND ADMINISTRATION

Recent MI, Recent Stroke, or Established Peripheral Arterial Disease

The recommended daily dose of PLAVIX is 75 mg once daily.

Acute Coronary Syndrome

For patients with non-ST-segment elevation acute coronary syndrome (unstable angina/non-Q-wave MI), PLAVIX should be initiated with a single 300 mg loading dose and then continued at 75 mg once daily. Aspirin (75 mg-325 mg once daily) should be initiated and continued in combination with PLAVIX. In CURE, most patients with Acute Coronary Syndrome also received heparin acutely (see **CLINICAL STUDIES**).

For patients with ST-segment elevation acute myocardial infarction, the recommended dose of PLAVIX is 75 mg once daily, administered in combination with aspirin, with or without thrombolytics. PLAVIX may be initiated with or without a loading dose (300 mg was used in CLARITY; see **CLINICAL STUDIES**).

PLAVIX can be administered with or without food.

No dosage adjustment is necessary for elderly patients or patients with renal disease. (See **Clinical Pharmacology: Special Populations.**)

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Brief Summary of Prescribing Information Revised February 2007

PLA-FEB07-B-Ae

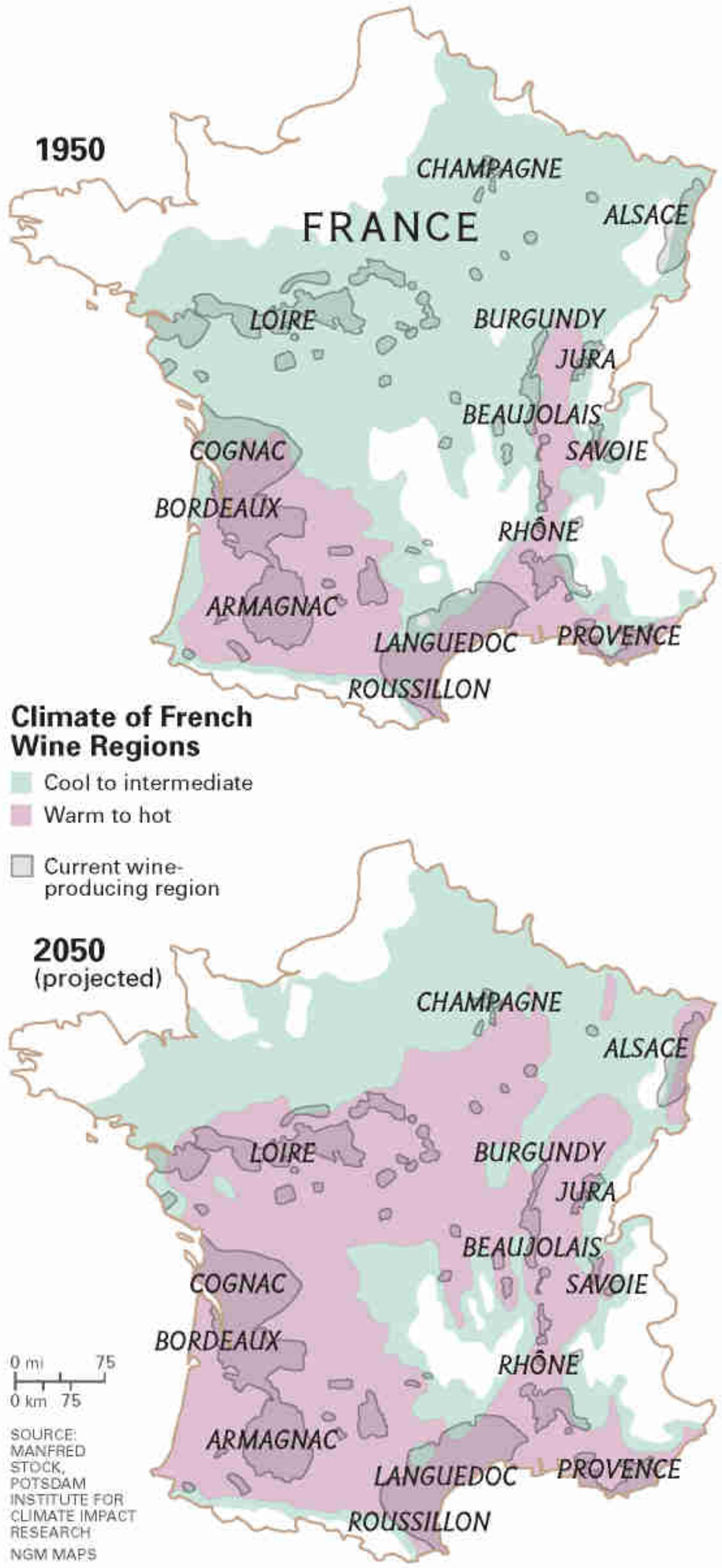
Grape Migration

Fifty years from now, will anyone get a kick from Champagne? If global temperatures continue to rise, an end-of-century world wine map could look so different that Cole Porter's lyrics may need a footnote: It got too darn hot for one of France's premier wine regions to cultivate grapes for its bubbly. But try the delicious vintage from the new wine-friendly climate of southern England!



A slew of studies predicts a dramatic shift in areas where wine grapes will thrive—or wither. If projections for higher temperatures remain on course, by the late 21st century, instead of planning a winery tour through a scorching Napa Valley, oenophiles might head north and west to coastal Puget Sound and British Columbia—or east to Ontario.

The predictions stem from the fact that each wine grape variety flourishes in a narrow climatic niche. The slow but steady temperature climb of past years means that many traditional wine regions are now near the limit of their optimal range, explains Gregory Jones, who studies the effect of climate on agriculture. To adapt, some Spanish vintners are planting at higher altitudes in the foothills of the Pyrenees. Germany, known for cool-weather white wines, is starting to produce warmer weather reds. One day, you might even stock a cellar with Scandinavian wines. *Skål!* —*Diane Cole*



CLIMATE CHANGE AND VITICULTURE, 1950-2099

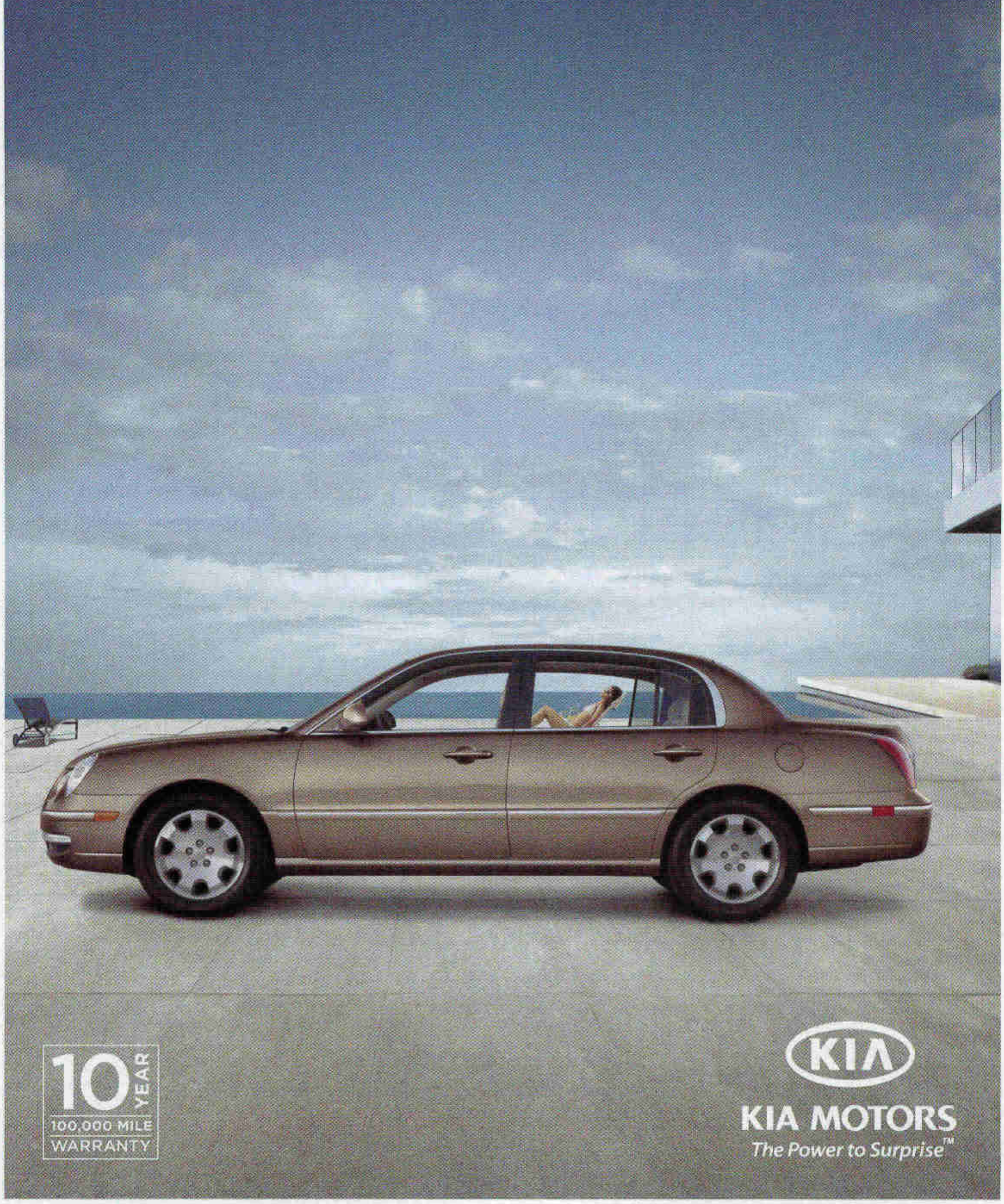


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WHERE IN THE WORLD?



"Fairy rings," found mainly along the edge of Namibia's Namib Desert, range from 7 to 30 feet in diameter.

Cryptic Desert Dimples Hundreds of circular patches of barren soil on the edge of the Namib Desert have long stumped scientists. Explanations for the enigmatic formations, which researchers have dubbed "fairy rings," have ranged from the esoteric (radioactive deposits) to the outlandish (UFO landing sites). But biochemist Carl Albrecht thinks he's close to proving what other scientists have suspected: Termites are to blame. He believes the subterranean insects release a chemical into the soil, rendering desert grasses susceptible to drought. The grasses die and blow away, leaving the empty patch. The ring then acts as a water catchment, which termites use to survive dry spells. *—Peter Gwin*

PHOTO: RICHARD DU TOIT

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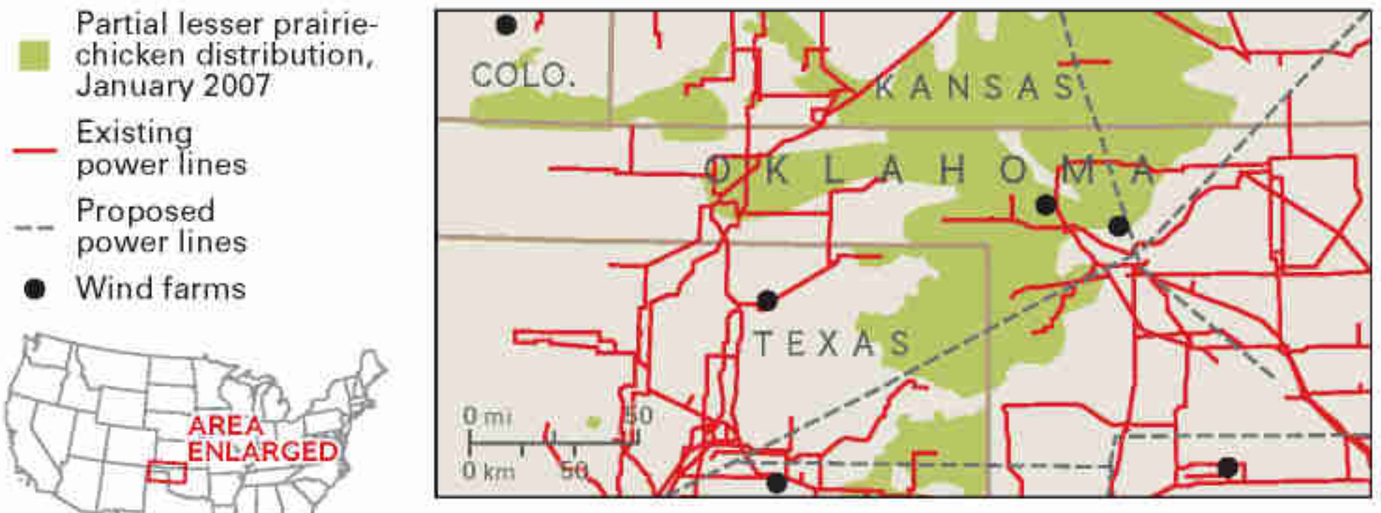
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Nowhere to Nest?

A lover of quiet, open spaces, the lesser prairie-chicken nests in remaining specks of America's native prairie. But those specks also have high winds that have lured wind farms, each with dozens of tall turbines (right). Naturalists fear lesser prairie-chickens may be driven off. The birds are picky—a Kansas study found that females prefer sites 400 yards from power transmission lines and half a mile from roads. They also shun buildings and agricultural fields. The result is a declining population. To protect the industry's Earth-friendly image, some developers don't want to put wind farms on the birds' territory. Meanwhile, as new power lines cross the prairie, wind farms will follow in their path. *—Helen Fields*





SOURCES: CHRIS HISE, THE NATURE CONSERVANCY; LESSER PRAIRIE-CHICKEN INTERSTATE WORKING GROUP, NGM MAPS



The lesser prairie-chicken (female, at right) is a candidate for listing as a threatened species because of habitat loss.

PHOTOS: JOEL SARTORE

LIMPOPO: 29º 11' SOUTH, 31º 01' EAST

CURIOSITY meets THE CAT



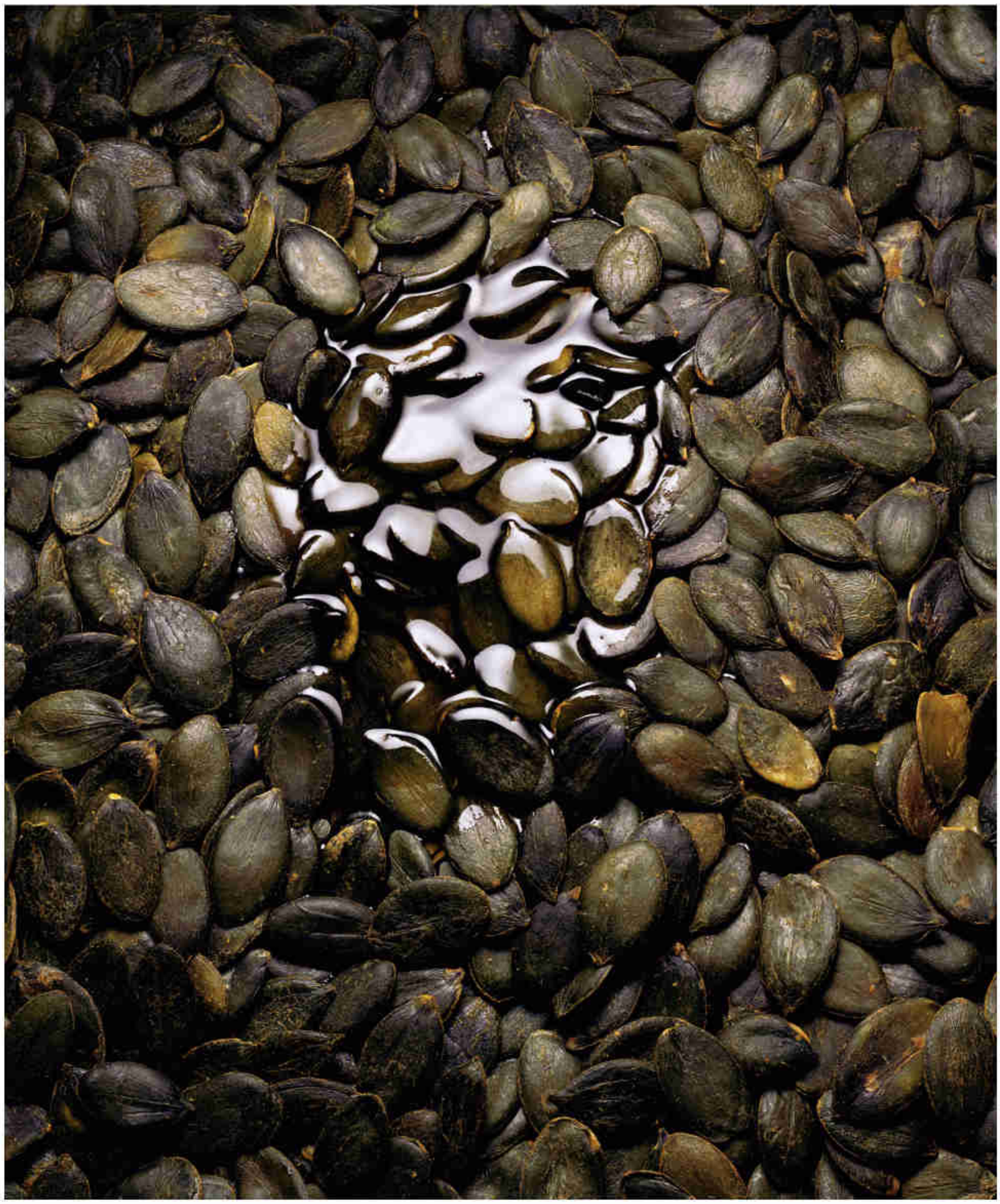


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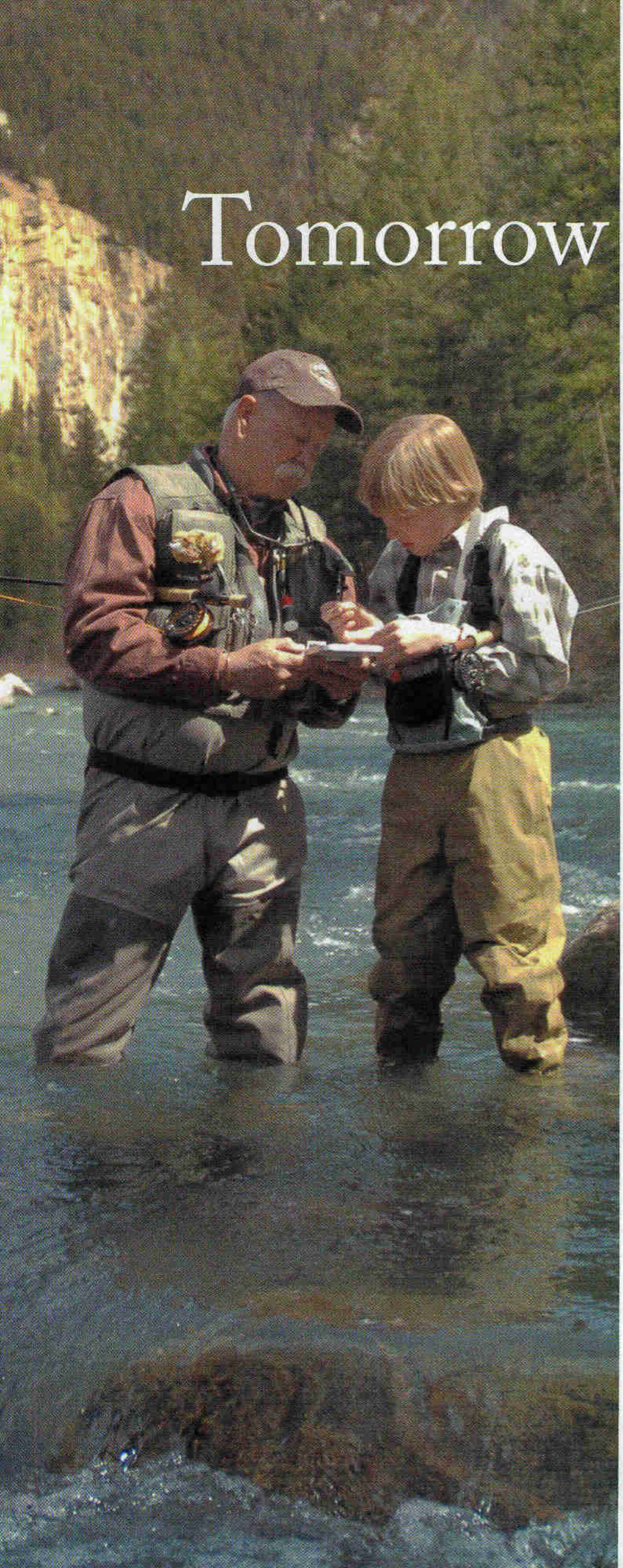
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Roasted and pressed, the seeds of 30 pumpkins yield 4 cups of heart-healthy oil.

Pumpkin Prize A Spanish explorer brought the first pumpkin home from the New World, circa 1500, and set off a health craze. An orange-green variety of the Halloween gourd known as the oil pumpkin, it has flesh too fibrous to eat. But in Austria, where it's grown in the province of Styria, the thick, green oil extracted from hull-less seeds has become a dietary staple, alleged to cure everything from baldness to bed-wetting. In 1773, the royal court limited the "precious" liquid to medicinal use. The court had a point. High in polyunsaturated fats, the oil is a good source of heart-healthy omega-3, says Kathy McManus, director of nutrition at Boston's Brigham and Women's Hospital. Its nutty flavor is hooking American chefs, who splash it on grilled foods, even on ice cream. U.S. sales could soar if kids only realized that drizzling it over eggs, Austrian-style, re-creates Dr. Seuss's classic dish. Just add ham. *—Linda Kulman*

PHOTO: MITCHELL FEINBERG



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Clad in a suit that pumps cold air, a photographer documents Mexico's steamy Cave of Crystals.

Crystalline Chapel Juan Manuel García-Ruiz is used to squinting at tiny crystals, the kind visible only with microscopes. So when he learned of a Mexican cave with crystals the size of buses, he had to see them—up close. "They are the biggest gypsum crystals in the world," says the Spanish crystallographer. Miners digging for silver and lead made the discovery in 2000: Their lights revealed an alien gallery of smooth, luminous crystals, some 36 feet long. Named the Cave of Crystals, the chamber lies 950 feet below the surface, simmering at 120°F. Visiting in 2002, García-Ruiz and a team of scientists explored the subterranean sauna in ten-minute shifts, then spent 20 minutes cooling off outside. In a paper published in April, he and his colleagues explain the cave was a perfect nursery for supersize crystals: For millennia it was flooded with mineral-rich water, which, in the warm, stable cave, allowed gypsum to form into massive moon-white beams. Says García-Ruiz, who hopes the mine owners preserve the cave for future visitors: "It's a masterwork of natural art—the Sistine Chapel of crystals." *—Neil Shea*



PHOTO: SPELEORESEARCH & FILMS, LA VENTA

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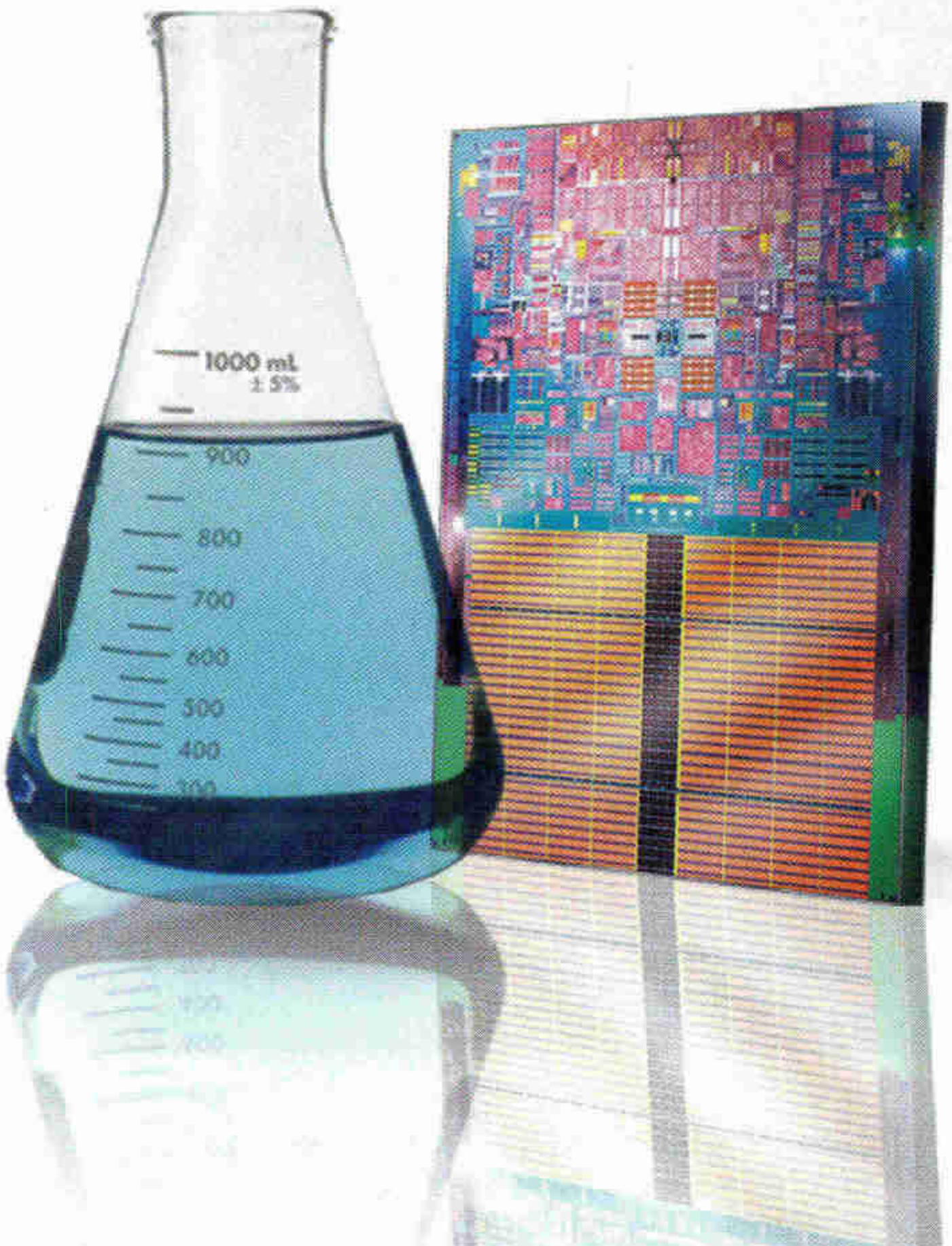
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Colonies in Crisis

Sweet, diligent honeybees—what would we do without you? Up with the sun, you flit from bloom to bloom, legs packed with pollen, helping flora to flourish. Bred from European stock brought over in the 1600s, your big social colonies are ideal for commercial pollination. You endure being trucked down highways to work giant farms.



Dancing out directions for hive mates, you service row upon row of almond, peach, pumpkin —nearly one hundred crops in all. And you provide honey to boot.

But since 2006, hundreds of thousands of U.S. honeybee colonies have died out in what is being called colony collapse disorder. Whether caused by a new insecticide, disease, or a mix of stressors, the losses have spurred a flurry of research and a query: Could native bees step in? Of the thousands of U.S. species, some adeptly tend crops like apples and alfalfa. A few, like the orchard mason bee, are already in commercial use. But some once common bees are in decline; data on others are spotty. Advocates are fighting to preserve wild and weedy lands that support these natives. Still, honeybees will remain workhorses for much of the world. "It's a numbers thing," says Jim Cane of Utah's Logan Bee lab. "You get tens of thousands of honeybees to work for such reasonable prices, it's hard to beat." *—Jennifer S. Holland*

THE BUZZ ON HONEYBEES

- Bees per hive: **up to 60,000**
- Bee hours for 1 lb. clover honey: **7,000+**
- U.S. honey yield, 2006: **155 million lbs.**
- U.S. diet tied to honeybee services: **33%**
- U.S. beekeepers reporting colony collapse disorder: **nearly 25%**
- Value of pollination: **$14.6 billion a year**

PHOTOS: MEUL, ARCO/NATURE PICTURE LIBRARY (ABOVE); RALPH A. CLEVENGER, CORBIS



Introducing a series on Meeting the Climate Challenge. For a close look at one option, biofuels, see "Green Dreams," page 38.

ESSAY BY **BILL McKIBBEN**

Carbon's New Math

To deal with global warming, the first step is to do the numbers.

Here's how it works. Before the industrial revolution, the Earth's atmosphere contained about 280 parts per million of carbon dioxide. That was a good amount—"good" defined as "what we were used to." Since the molecular structure of carbon dioxide traps heat near the planet's surface that would otherwise radiate back out to space, civilization grew up in a world whose thermostat was set by that number. It equated to a global average temperature of about 57 degrees Fahrenheit, which in turn equated to all the places we built our cities, all the crops we learned to grow and eat, all the water supplies we learned to depend on, even the passage of the seasons that, at higher latitudes, set our psychological calendars.

Once we started burning coal and gas and oil to power our lives, that 280 number started to rise. When we began measuring in the late 1950s, it had already reached the 315 level. Now it's at 380, and increasing by roughly two parts per million annually. That doesn't sound like very much, but it turns out that the extra heat that CO_2 traps, a couple of watts per square meter of the Earth's surface, is

Never mind the steam spewing from a coal-fired power plant. The problem is what you can't see: greenhouse gases, mainly CO_2. Plants like this generate a quarter of humankind's CO_2 emissions.

MITCH EPSTEIN, GETTY IMAGES

Global warming presents the greatest test humans have yet faced. New technologies and new habits offer some promise, but only if we move quickly and decisively.

enough to warm the planet considerably. We've raised the temperature more than a degree Fahrenheit already. It's impossible to precisely predict the consequences of any further increase in CO_2 in the atmosphere. But the warming we've seen so far has started almost everything frozen on Earth to melting; it has changed seasons and rainfall patterns; it's set the sea to rising.

No matter what we do now, that warming will increase some—there's a lag time before the heat fully plays out in the atmosphere. That is, we can't stop global warming. Our task is less inspiring: to contain the damage, to keep things from getting out of control. And even that is not easy. For one thing, until recently there's been no clear data suggesting the point where catastrophe looms. Now we're getting a better picture—the past couple of years have seen a series of reports indicating that 450 parts per million CO_2 is a threshold we'd be wise to respect. Beyond that point, scientists believe future centuries will likely face the melting of the Greenland and West Antarctic ice sheets and a subsequent rise in sea level of giant proportion. Four hundred fifty parts per million is still a best guess (and it doesn't include the witches' brew of other, lesser, greenhouse gases like methane and nitrous oxide). But it will serve as a target of sorts for the world to aim at. A target that's moving, fast. If concentrations keep increasing by two parts per million per year, we're only three and a half decades away.

Bill McKibben's 11th book on environmental topics, The Bill McKibben Reader: Pieces from an Active Life, *will be published this winter.*

So the math isn't complicated—but that doesn't mean it isn't intimidating. So far only the Europeans and Japanese have even begun to trim their carbon emissions, and they may not meet their own modest targets. Meanwhile, U.S. carbon emissions, a quarter of the world's total, continue to rise steadily—earlier this year we told the United Nations we'd be producing 20 percent more carbon in 2020 than we had in 2000. China and India are suddenly starting to produce huge quantities of CO_2 as well. On a per capita basis (which is really the only sensible way to think about the morality of the situation), they aren't anywhere close to American figures, but their populations are so huge, and their economic growth so rapid, that they make the prospect of a worldwide decline in emissions seem much more daunting. The Chinese are currently building a coal-fired power plant every week or so. That's a lot of carbon.

Everyone involved knows what the basic outlines of a deal that could avert catastrophe would look like: rapid, sustained, and dramatic cuts in emissions by the technologically advanced countries, coupled with large-scale technology transfer to China, India, and the rest of the developing world so that they can power up their emerging economies without burning up their coal. Everyone knows the big questions, too: Are such rapid cuts even possible? Do we have the political will to make them and to extend them overseas?

The first question—is it even possible?—is usually addressed by fixating on some single new technology (hydrogen! ethanol!) and imagining it will solve our troubles. But the scale of the problem means we'll need many strategies. Three years ago a Princeton team made one of the best assessments of the possibilities. Stephen Pacala and Robert Socolow published a paper in *Science* detailing 15 "stabilization wedges"—changes big enough to really matter, and for which the technology was already available or clearly on the horizon. Most people have heard of some of them: more fuel-efficient cars, better-built homes, wind turbines, biofuels like ethanol. Others are newer and less sure: plans for building coal-fired power plants that can separate carbon from the



SOYBEANS



WIND TURBINE



SOLAR PANEL



COMPACT FLUORESCENT BULB

exhaust so it can be "sequestered" underground.

These approaches have one thing in common: They're more difficult than simply burning fossil fuel. They force us to realize that we've already had our magic fuel and that what comes next will be more expensive and more difficult. The price tag for the global transition will be in the trillions of dollars. Of course, along the way it will create myriad new jobs, and when it's complete, it may be a much more elegant system. (Once you've built the windmill, the wind is free; you don't need to guard it against terrorists or build a massive army to control the countries from which it blows.) And since we're wasting so much energy now, some of the first tasks would be relatively easy. If we replaced every incandescent bulb that burned out in the next decade anyplace in the world with a compact fluorescent, we'd make an impressive start on one of the 15 wedges. But in that same decade we'd need to build 400,000 large wind turbines—clearly possible, but only with real commitment. We'd need to follow the lead of Germany and Japan and seriously subsidize rooftop solar panels; we'd need to get most of the world's farmers plowing their fields less, to build back the carbon their soils have lost. We'd need to do everything all at once.

As precedents for such collective effort, people sometimes point to the Manhattan Project to build a nuclear weapon or the Apollo Program to put a man on the moon. But those analogies don't really work. They demanded the intense concentration of money and intelligence on a single small niche in our technosphere. Now we need almost the opposite: a commitment to take what we already know how to do and somehow spread it into every corner of our economies, and indeed our most basic activities. It's as if NASA's goal had been to put all of us on the moon.

Not all the answers are technological, of course—maybe not even most of them. Many of the paths to stabilization run straight through our daily lives, and in every case they will demand difficult changes. Air travel is one of the fastest growing sources of carbon emissions around the world, for instance, but even many of us who are noble about changing lightbulbs and happy to drive hybrid cars chafe at the thought of not jetting around the country or the world. By now we're used to ordering take-out food from every corner of the world every night of our lives—according to one study, the average bite of food has traveled nearly 1,500 miles before it reaches an American's lips, which means it's been marinated in (crude) oil. We drive alone, because it's more convenient than adjusting our schedules for public transit. We build ever bigger homes even as our family sizes shrink, and we watch ever

CLOCKWISE FROM TOP LEFT: ROBERT CLARK; JORG GREUEL, GETTY IMAGES; ROBERT CLARK; VICTORIA SNOWBER, GETTY IMAGES

bigger TVs, and—well, enough said. We need to figure out how to change those habits.

Probably the only way that will happen is if fossil fuel costs us considerably more. All the schemes to cut carbon emissions—the so-called cap-and-trade systems, for instance, that would let businesses bid for permission to emit—are ways to make coal and gas and oil progressively more expensive, and thus to change the direction in which economic gravity pulls when it applies to energy. If what we paid for a gallon of gas reflected even a portion of its huge environmental cost, we'd be driving small cars to the train station, just like the Europeans. And we'd be riding bikes when the sun shone.

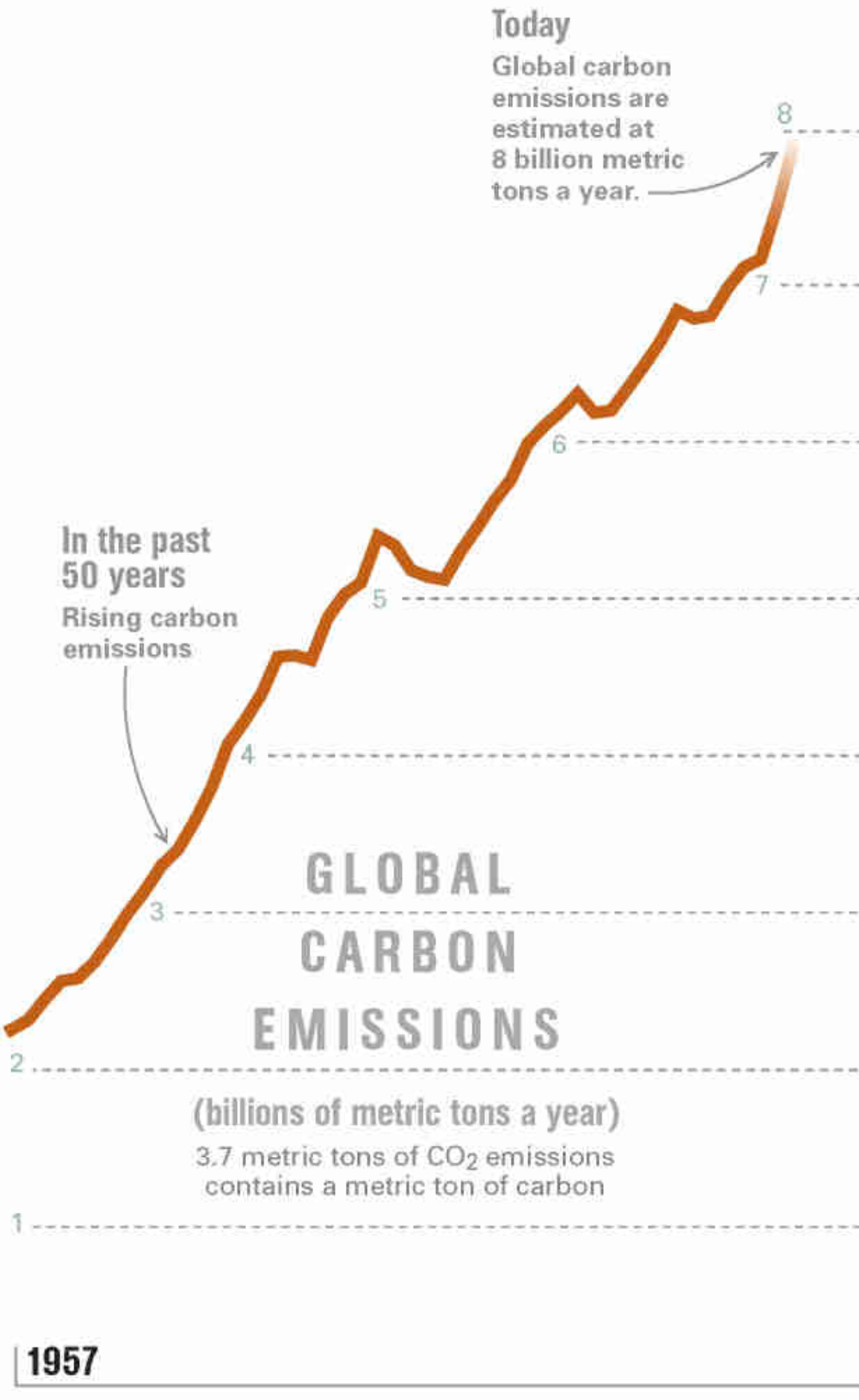
The most straightforward way to raise the price would be a tax on carbon. But that's not easy. Since everyone needs to use fuel, it would be regressive—you'd have to figure out how to keep from hurting poor people unduly. And we'd need to be grown-up enough to have a real conversation about taxes—say, about switching away from taxes on things we like (employment) to taxes on things we hate (global warming). That may be too much to ask for—but if it is, then what chance is there we'll be able to take on the even more difficult task of persuading the Chinese, the Indians, and all who are lined up behind them to forgo a coal-powered future in favor of something more manageable? We know it's possible—earlier this year a UN panel estimated that the total cost for the energy transition, once all the pluses and minuses were netted out, would be just over 0.1 percent of the world's economy each year for the next quarter century. A small price to pay.

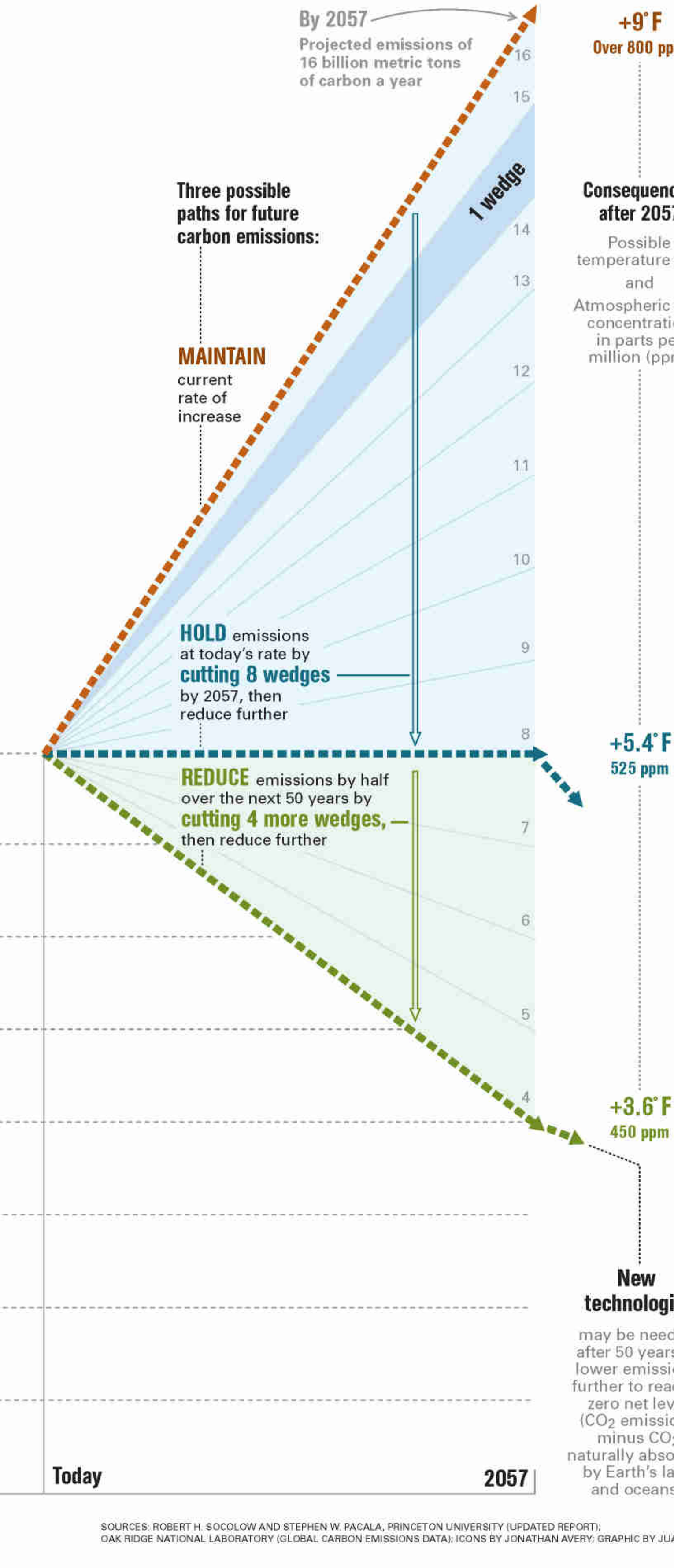
In the end, global warming presents the greatest test we humans have yet faced. Are we ready to change, in dramatic and prolonged ways, in order to offer a workable future to subsequent generations and diverse forms of life? If we are, new technologies and new habits offer some promise. But only if we move quickly and decisively—and with a maturity we've rarely shown as a society or a species. It's our coming-of-age moment, and there are no certainties or guarantees. Only a window of possibility, closing fast but still ajar enough to let in some hope. □

Warming Trends For more on climate from National Geographic and NPR, visit **ngm.com/climateconnections** and **npr.org/climateconnections.**

How to Cut Emissions

Scientists warn that current CO_2 emissions should be cut by at least half over the next 50 years to avert a future global warming disaster. Princeton researchers Robert Socolow and Stephen Pacala have described 15 "stabilization wedges" (far right) to realize that goal using existing technologies. Each carbon-cutting wedge would reduce emissions by a billion metric tons a year by 2057. Adopting any combination of these strategies that equals 12 wedges could lower emissions 50 percent.





+9˚F
Over 800 ppm

+5.4˚F
525 ppm

+3.6˚F
450 ppm

Consequences after 2057

Possible temperature rise and Atmospheric CO_2 concentration in parts per million (ppm)

New technologies

may be needed after 50 years to lower emissions further to reach a zero net level (CO_2 emissions minus CO_2 naturally absorbed by Earth's land and oceans).

ONE WEDGE AT A TIME

Each strategy listed below would, by 2057, reduce annual carbon emissions by a billion metric tons.

EFFICIENCY AND CONSERVATION

- Improve fuel economy of the two billion cars expected on the road by 2057 to 60 mpg from 30 mpg.
- Reduce miles traveled annually per car from 10,000 to 5,000.
- Increase efficiency in heating, cooling, lighting, and appliances by 25 percent.
- Improve coal-fired power plant efficiency to 60 percent from 40 percent.

CARBON CAPTURE AND STORAGE

- Introduce systems to capture CO_2 and store it underground at 800 large coal-fired plants or 1,600 natural-gas-fired plants.
- Use capture systems at coal-derived hydrogen plants producing fuel for a billion cars.
- Use capture systems in coal-derived synthetic fuel plants producing 30 million barrels a day.

LOW-CARBON FUELS

- Replace 1,400 large coal-fired power plants with natural-gas-fired plants.
- Displace coal by increasing production of nuclear power to three times today's capacity.

RENEWABLES AND BIOSTORAGE

- Increase wind-generated power to 25 times current capacity.
- Increase solar power to 700 times current capacity.
- Increase wind power to 50 times current capacity to make hydrogen for fuel-cell cars.
- Increase ethanol biofuel production to 50 times current capacity. About one-sixth of the world's cropland would be needed.
- Stop all deforestation.
- Expand conservation tillage to all cropland (normal plowing releases carbon by speeding decomposition of organic matter).

SOURCES: ROBERT H. SOCOLOW AND STEPHEN W. PACALA, PRINCETON UNIVERSITY (UPDATED REPORT); OAK RIDGE NATIONAL LABORATORY (GLOBAL CARBON EMISSIONS DATA); ICONS BY JONATHAN AVERY; GRAPHIC BY JUAN VELASCO, NGM ART

Green Dreams

Making fuel from crops could be good for the planet—after a breakthrough or two.

Garbed against scratches and snakes, a worker cuts sugarcane in Brazil, where half the harvest is refined into fuel alcohol for cars. Biofuel fever struck early in Brazil; now it's spreading worldwide.





BY **JOEL K. BOURNE, JR.**
NATIONAL GEOGRAPHIC STAFF

PHOTOGRAPHS BY **ROBERT CLARK**

When Dario Franchitti steered his sleek, 670-horsepower, orange-and-black Indy car to victory at this year's Indianapolis 500, the ebullient Scotsman chalked up an odd footnote in sports history. He became the first driver ever to win the iconic American auto race on pure ethanol—the gin-clear, high-octane corn hooch that supporters from midwestern farmers to high-ranking politicians hope will soon replace gasoline as America's favorite motor fuel.

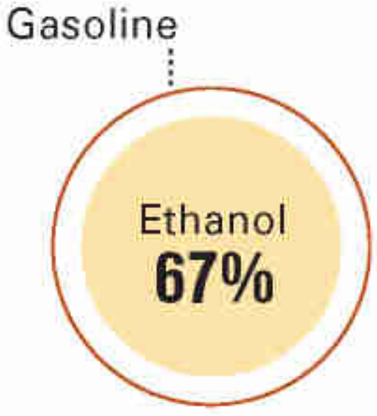
Indy's switch back to the old bootlegger's friend is just one indicator of the mad rush to biofuels, homegrown gasoline and diesel substitutes made from crops like corn, soybeans, and sugarcane. Proponents say such renewable fuels could light a fire under our moribund rural economy, help extract us from our sticky dependence on the Middle East, and—best of all—cut our ballooning emissions of carbon dioxide. Unlike the ancient carbon unlocked by the burning of fossil fuels, which is driving up Earth's thermostat by the minute, the carbon in biofuels comes from the atmosphere, captured by plants during the growing season. In theory, burning a tank of ethanol could make driving even an Indy car carbon neutral.

The operative word is "could." Biofuels as currently rendered in the U.S. are doing great things for some farmers and for agricultural giants like Archer Daniels Midland and Cargill, but little for the environment. Corn requires large doses of herbicide and nitrogen fertilizer and can cause more soil erosion than any other crop. And producing corn ethanol consumes just about as much fossil fuel as the ethanol itself replaces. Biodiesel from soybeans fares only slightly better. Environmentalists also fear that rising prices for both crops will push farmers to plow up some 35 million acres of marginal farmland now set aside for soil and wildlife conservation, potentially releasing even more carbon bound in the fallow fields.

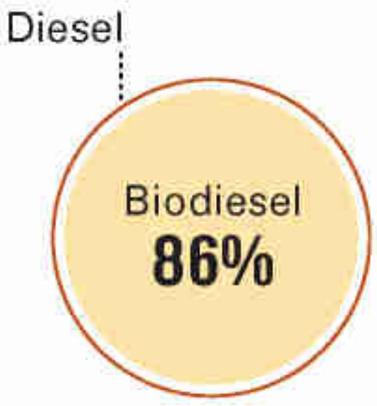
The boom has already pushed corn prices to heights not seen in years, spurring U.S. growers to plant the largest crop since World War II. Around a fifth of the harvest will be brewed into ethanol—more than double the amount only five years ago. Yet such is the thirst for gasoline among SUV-loving

ENERGY CONTENT

In a gallon of ethanol compared with a gallon of gasoline



In a gallon of biodiesel compared with a gallon of diesel



SOURCE: U.S. ENERGY INFORMATION ADMINISTRATION

A beaker of ethanol, aka grain alcohol, burns brightly, revealing its energy potential. Ethanol and biodiesel are now made from food crops like corn and soybeans, but in principle any plant material will do.

Americans that even if we turned our entire corn and soybean crops into biofuels, they would replace just 12 percent of our gasoline and a paltry 6 percent of our diesel, while squeezing supplies of corn- and soy-fattened beef, pork, and poultry. Not to mention Corn Flakes.

Still, the prospect of amber waves of home-grown energy crops is too seductive to ignore, especially given the example of Brazil. Thirty years after launching a crash program to replace gasoline with ethanol from sugarcane, Brazil announced last year that thanks to ethanol and rising domestic oil production, it had weaned itself off imported oil. Investors, led by superstar CEOs Richard Branson of Virgin Atlantic and Vinod Khosla of Sun Microsystems fame, have bought into the vision, sinking more than 70 billion dollars into renewable energy companies. The U.S. government has ponied up hefty ethanol subsidies, and President Bush has proposed over 200 million dollars for research, with a goal of replacing 15 percent of our projected gasoline use with ethanol and other fuels by 2017.

"We can create ethanol in an incredibly dumb way," says Nathanael Greene, a senior researcher with the Natural Resources Defense Council. "But there are many pathways that get us a future full of wildlife, soil carbon, and across-the-board benefits." The key, Greene and others say, is to figure out how to make fuel from plant material other than food: cornstalks, prairie grasses, fast-growing trees, or even algae. That approach, combined with more efficient vehicles and communities, says Greene, "could eliminate our demand for gasoline by 2050."

A century ago, Henry Ford's first car ran on alcohol, while Rudolf Diesel fired his namesake engine with peanut oil. But both inventors soon discovered that "rock oil," when slightly refined, held far more bang per gallon than plant fuel, and was cheap to boot. Oil soon left plant fuels in the dust. Only in periods of scarcity—like the OPEC oil embargo of 1973—did the U.S. and other countries turn back to ethanol, mixing it into gasoline to stretch supplies.

It wasn't until 2000 that fuel alcohol staged a major comeback, largely as an additive in less polluting gasoline blends. For years, ethanol producers had enjoyed heavy subsidies and protective tariffs on imports, while Archer Daniels Midland, the largest U.S. ethanol producer, advocated mixing ethanol into motor fuel. But ethanol ran into stiff competition with the oil industry's own additive, methyl tertiary-butyl ether (MTBE).

Then MTBE, a suspected cancer agent, began turning up in aquifers, prompting many states to ban the chemical and suddenly creating a two-billion-gallon market for ethanol. Recently, with the Middle East in turmoil and oil security once again a hot issue, Congress gave the ethanol industry another boost, extending the tax credits and tariffs while requiring that 7.5 billion gallons of the nation's fuel come from ethanol or biodiesel by 2012. (That figure could rise to 60 billion gallons by 2030 if some senators have their way.) The biofuels boom was on.

Ethanol enthusiasts point out that the oil industry has also reaped huge subsidies for decades, including billions of dollars a year in tax breaks, as well as tens of billions of dollars annually to defend oil fields in the Middle East—even before the war in Iraq. Not to mention the untallied costs to health and the environment of pollution from cars, trucks, and the oil industry itself. And while oil subsidies flow into the hands of the wealthiest companies in the world, ethanol subsidies are fueling a renaissance in small heartland towns with names like Wahoo, Nebraska.

By this summer, with Nebraska's 16 ethanol plants gearing up to consume a third of the state's crop, corn prices had doubled, briefly topping four dollars a bushel, and growers were looking forward to the best profits in memory. "This is the first year I've planted all corn and no beans," says Roger Harders as he finishes lunch at the Wigwam Café in Wahoo. He also has cattle

This is New York–based photographer Robert Clark's second cover story for 2007. He has now resolved to reduce his carbon footprint by biking and recycling.

"This is the first year I've planted all corn and no beans. You're almost tempted to get out of the cattle business and sell your corn outright." ROGER HARDERS, NEBRASKA FARMER



Amber waves of corn sprawl across a storage lot in Fremont, Nebraska. Last year corn from this pile fed California dairy cows. This year it's heading for a nearby ethanol plant. Nebraska's 16 distilleries will consume a third of the state's crop this year—and 50 more are planned.

that this year will eat a lot more grass than four-dollar corn. "You're almost tempted to get out of the cattle business and sell your corn outright."

Gary Rasmussen, co-owner of the local Case-IH implement dealership, sold ten new corn harvesters at upwards of $200,000 each from December through February, twice as many as usual, and his tractor sales are up as well. A computer screen showing the latest corn prices is on prominent display on the sales floor. "Anytime you see a surge in commodity markets, you see a brighter future," says Rasmussen. "Ethanol is going to be a real driver."

Despite the boom, it's hard to fill up with ethanol in the U.S. It's still mainly a gasoline additive. Only about 1,200 stations scattered mostly across the corn belt sell ethanol, in the form of E85 (85 percent ethanol, 15 percent gas), which can be burned only in specially designed engines. Ethanol delivers 30 percent fewer miles a gallon than gasoline, but at around $2.80 a gallon in the heartland, it is competitive with $3.20-a-gallon gas. Since the U.S. has no major pipelines for ethanol, transportation by truck, rail, or barge drives up the price elsewhere. But more ethanol plants are popping up all the time.

Christine Wietzki, a former farm kid from western Nebraska, is technical manager for one of the newest and most advanced ethanol plants in the country, the E3 BioFuels plant in tiny

Mead, Nebraska, population 564. She's spent much of her young career turning food into fuel and believes it's a good deal all around. "If we don't have to export corn and can use it to get off foreign oil, that's fantastic," she says. In a cold spring downpour, Wietzki shows off the plant, a cluster of new white buildings, tanks, and a grain bin rising from thick gray mud next to a pungent, 30,000-cow feedlot.

Much of what happens in its tanks and pipes is typical of any large distillery—after all, people have been turning grain into alcohol for eons. The corn is ground, mixed with water, and heated; added enzymes convert the starch into sugars. In a fermentation tank, yeast gradually turns the sugars into alcohol, which is separated from the water by distillation. The leftover, known as distillers' grains, is fed to the cows, and some of the wastewater, high in nitrogen, is applied to fields as a fertilizer.

The process also gives off large amounts of carbon dioxide, and that's where ethanol's green label starts to brown. Most ethanol plants burn natural gas or, increasingly, coal to create the steam that drives the distillation, adding fossil-fuel emissions to the carbon dioxide emitted by the yeast. Growing the corn also requires nitrogen fertilizer, made with natural gas, and heavy use of diesel farm machinery. Some studies of the energy balance of corn ethanol—the amount of fossil energy needed to make ethanol versus the energy it produces—suggest that ethanol is a loser's game, requiring more carbon-emitting fossil fuel than it displaces. Others give it a slight advantage. But however the accounting is done, corn ethanol is no greenhouse panacea.

"Biofuels are a total waste and misleading us from getting at what we really need to do: conservation," says Cornell University's David Pimentel, who is one of ethanol's harshest critics. "This is a threat, not a service. Many people are seeing this as a boondoggle."

But Wietzki and her colleagues in Mead think they can do better. They hope to improve the energy balance and greenhouse gas benefits of ethanol by creating a closed-loop system—which

Corn ethanol



Nearly all the ethanol in the U.S. is brewed from yellow feed corn. Proliferating ethanol distilleries are already competing for corn with meat producers, driving up prices. Most ethanol is sold as a gasoline additive or, in the Midwest, as E85 (85 percent ethanol, 15 percent gasoline).

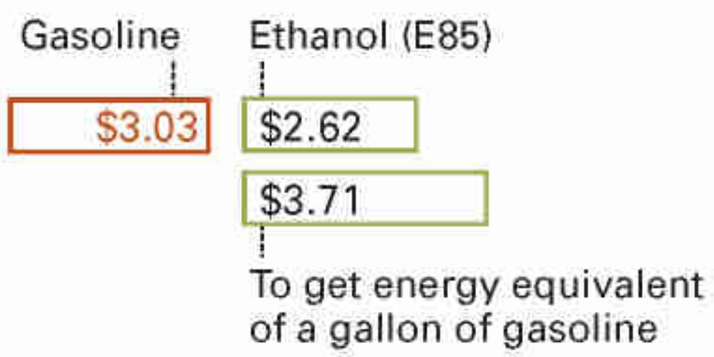
U.S. PRODUCTION

4.86 billion gallons (2006)

U.S. PRODUCTION COST

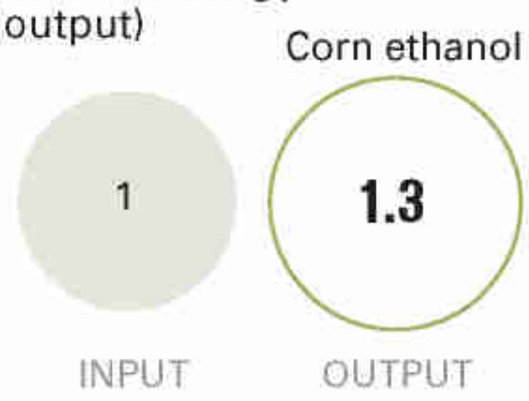
$1.09 per gallon

U.S. RETAIL PRICE (per gallon, July 2007)

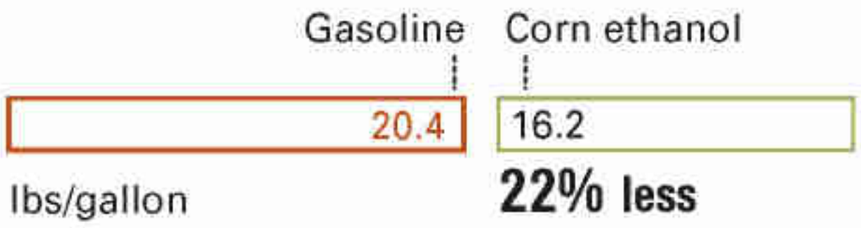


ENERGY BALANCE

Fossil-fuel energy used to make the fuel (input) compared with the energy in the fuel (output)

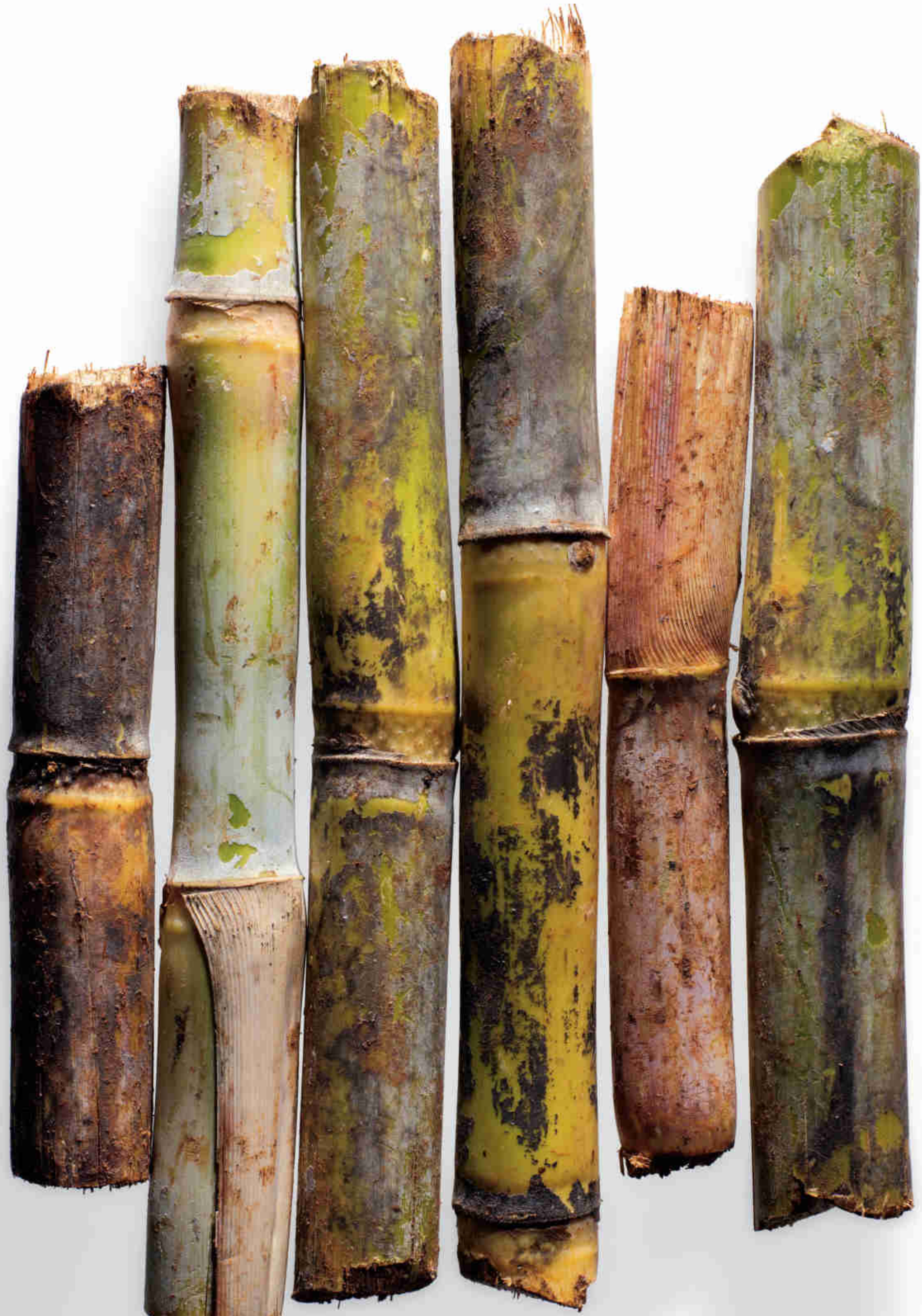


GREENHOUSE GAS EMISSIONS (production and use)



SOURCES: U.S. DEPARTMENT OF ENERGY; U.S. ENVIRONMENTAL PROTECTION AGENCY; RENEWABLE FUELS ASSOCIATION; ENERGY FUTURE COALITION; WORLDWATCH INSTITUTE





Cane ethanol

Brazil rivals the U.S. in ethanol production because sugarcane yields 600 to 800 gallons an acre, twice as much as corn. The stalk is 20 percent sugar—fermented to make the alcohol—and the waste cane can be burned to power the distillery, lowering fossil-fuel use.



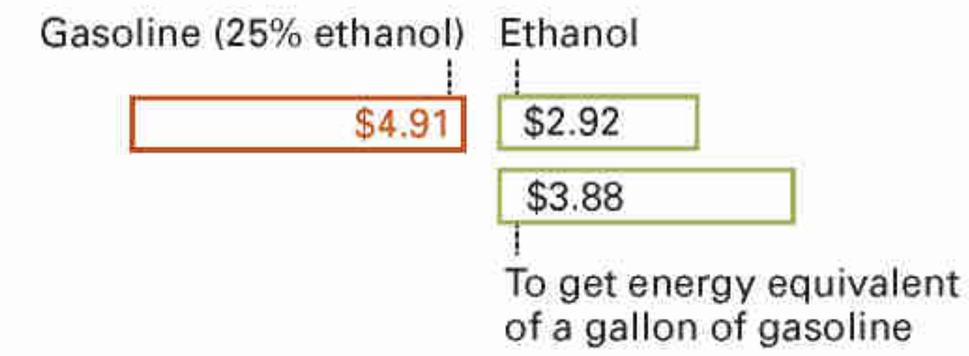
BRAZIL PRODUCTION

3.96 billion gallons (2005)

BRAZIL PRODUCTION COST

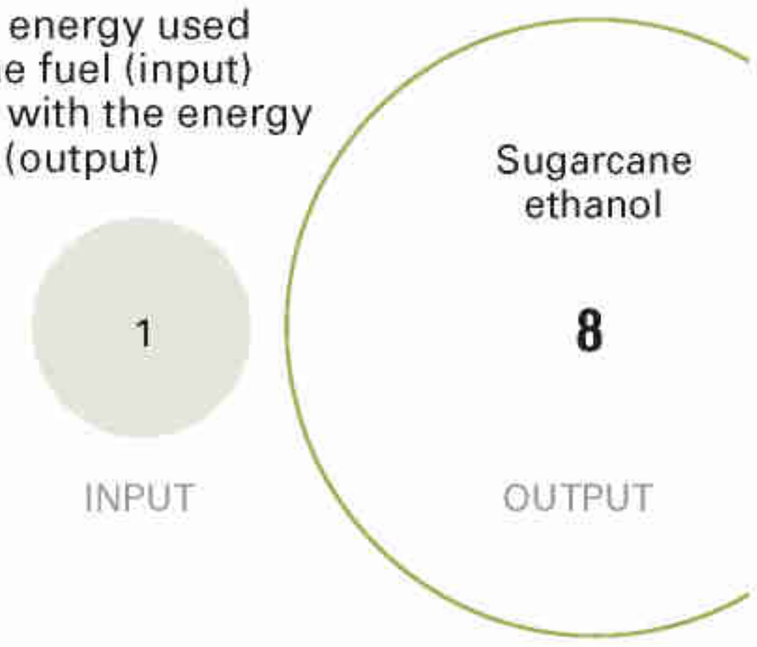
$0.87 per gallon

BRAZIL RETAIL PRICE (per gallon, June 2007)

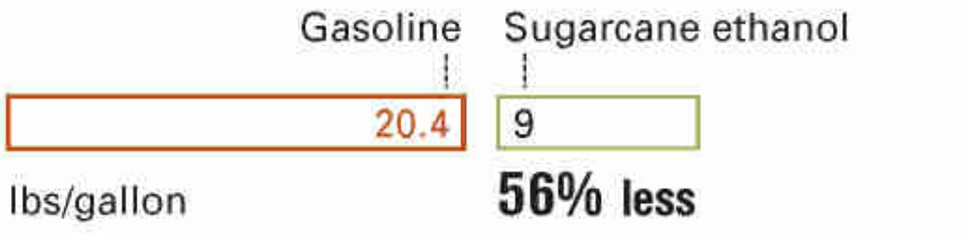


ENERGY BALANCE

Fossil-fuel energy used to make the fuel (input) compared with the energy in the fuel (output)



GREENHOUSE GAS EMISSIONS (production and use)



SOURCES: U.S. DOE, U.S. EPA; WORLDWATCH INSTITUTE; IOWA STATE UNIVERSITY

is where those cows come in. They plan to fire their boilers with methane from two giant four-million-gallon biodigesters fed with cattle manure from the feedlot next door—in effect using biogas to make biofuel. The increased efficiency, she says, isn't only good for the environment, it's also good business, especially if the price of corn keeps rising or oil drops below $45 a barrel or so, the lowest price at which ethanol backers say the fuel can compete with gasoline in the U.S. "The last people standing," Wietzki says, "will be highly efficient producers like us."

It's easy to lose faith in biofuels if corn ethanol is all you know. A more encouraging picture unfolds some 5,500 miles southeast of Mead, where the millions of drivers of São Paulo, Brazil, spend hours a day jammed to a standstill in eight lanes of traffic, their engines, if not their tempers, idling happily on *álcool* from Brazil's sprawling sugar belt. The country had been burning some ethanol in its vehicles since the 1920s, but by the 1970s it was importing 75 percent of its oil. When the OPEC oil embargo crippled the nation's economy, Brazil's dictator at the time—Gen. Ernesto Geisel—decided to kick the country's oil habit. The general heavily subsidized and financed new ethanol plants, directed the state-owned oil company, Petrobras, to install ethanol tanks and pumps around the country, and offered tax incentives to Brazilian carmakers to crank out cars designed to burn straight ethanol. By the mid-1980s, nearly all the cars sold in Brazil ran exclusively on álcool.

Formula One–loving Brazilian drivers embraced the cars, especially since pure ethanol has an octane rating of around 113. It burns best at much higher compression than gasoline, allowing alcohol engines to crank out more power. Best of all, the government subsidies made it significantly cheaper. Not that ethanol didn't hit a few bumps in the road. By the early 1990s, low oil prices led the government to phase out the subsidies, and high sugar prices left the sugar mills, or *usinas*, with no incentive to produce the fuel. Millions of alcohol car drivers like

Roger Guilherme, now a supervising engineer at Volkswagen-Brazil, were left high and dry.

"Guys like me had to wait in long lines two hours or more to fuel up," Guilherme says in his office at the massive Volkswagen plant in São Bernardo do Campo. "Consumers lost confidence in the alcohol program." A decade later when oil prices started to rise, Brazilians wanted to burn alcohol again, but given their past experience, they didn't want to be wedded to it. So Guilherme's bosses gave him a challenge: Find an inexpensive way for one car to burn both fuels. Guilherme's team worked with engineers at Magneti Marelli, which supplies fuel systems to Volkswagen, to write new software for the engine's electronic control unit that could automatically adjust the air-fuel ratio and spark advance for any mixture of gasoline and alcohol. Volkswagen introduced Brazil's first TotalFlex vehicle in 2003, modifying a small soccer ball of a commuter car called the Gol, which means—you guessed it—"goal!" It was an instant hit, and soon every other carmaker in Brazil followed suit.

Today, nearly 85 percent of cars sold in Brazil are flex: small, sporty designs that zip around the lumbering, diesel-belching trucks in São Paulo. You can even get a flex Transporter—the beloved loaf-shaped VW van, still made here. With a liter of alcohol running an average of one Brazilian real cheaper than gasoline at the pump, most flex cars haven't burned gas in years.

Sugarcane, not engine technology, is the real key to Brazil's ethanol boom. The sweet, fast-growing tropical grass has been a staple export for the country since the 1500s. Unlike corn, in which the starch in the kernel has to be broken down into sugars with expensive enzymes before it can be fermented, the entire sugarcane stalk is already 20 percent sugar—and it starts to ferment almost as soon as it's cut. Cane yields 600 to 800 gallons of ethanol an acre, more than twice as much as corn.

Usina São Martinho, one of the largest sugar mills and ethanol distilleries in the world, sits in the heart of the emerald desert, as one São Paulo columnist has dubbed Brazil's prime sugarcane



"If alcohol is a 'clean' fuel, the process of making it is very dirty, especially the burning of cane and the exploitation of the cane workers." MARCELO PEDROSO GOULART, SÃO PAULO PROSECUTOR



Blackened by soot, a cane cutter in São Paulo state aims to harvest ten tons a day—earning $250 a week—in a field burned to ease his work. Mechanical harvesters are replacing muscle and fire in Brazil's sugar belt, likely to double in area within ten years as ethanol demand rises.



In a living sea of green, a laborer takes a break from weeding on an organic sugarcane farm in central Brazil that produces 150 million liters of fuel alcohol each year. Ethanol provides 40 percent of Brazil's fuel for cars and light trucks.

"We're obsessed with efficiency," says plant director Agenor Cunha Pavan. Even the cane trucks and other machinery burn ethanol mixed with diesel. A crop duster burns pure alcohol.



Lighting up the night near Pradópolis, Brazil, Usina São Martinho is one of the largest ethanol refineries in the world, producing 300 million liters annually—without relying on fossil fuel or electricity from the grid. For heat and power, the plant burns sugarcane waste.

region in central São Paulo state. The rolling fields are carpeted with cane for as far as the eye can see. Each year the mammoth plant turns seven million tons of cane into 300 million liters of ethanol for Brazilian cars and 500,000 tons of sugar, bound mainly for Saudi Arabia. To meet growing demand for ethanol both here and abroad, the company is also building a three-million-ton unit—exclusively for ethanol—in the rapidly expanding cane fields of Goiás state.

Growers in the emerald desert can get seven harvests from their fields before replanting, and the distilleries recycle their wastewater into fertilizer. Like most of Brazil's usinas, São Martinho consumes no fossil fuel or electricity from the grid; for heat and power it burns cane waste, known as *bagasse*, typically generating a slight surplus of power. Even the cane trucks and agricultural machinery burn a blend of diesel and ethanol, while the favorite crop duster, a hot little plane called the *Ipanema*, is the first fixed-wing aircraft built to burn pure alcohol. "We're obsessed with efficiency," says plant director Agenor Cunha Pavan.

While corn ethanol's energy ratio hovers around breakeven, "we get eight units of ethanol for every one unit of fossil fuel," says Isaias Macedo, one of Brazil's leading sugarcane researchers. Experts estimate that producing and burning cane ethanol generates anywhere from 55 to 90

percent less carbon dioxide than gasoline. And Macedo envisions even greater efficiencies. "We can do the same thing with two-thirds or half of the bagasse, better manage tractors in the field, and approach levels of 12 or 13."

Even sugarcane isn't without its problems. While nearly all of São Martinho's cane is machine harvested, most Brazilian cane is cut by hand; the work, though well paid, is hot, dirty, and backbreaking. Cutters die of exhaustion every year, say leaders of their union. And to kill snakes and make the cane easier to cut by hand, the fields are usually burned before harvest, filling the air with soot while releasing methane and nitrous oxide, two potent greenhouse gases.

The expansion of Brazil's cane acreage—set to nearly double over the next decade—may also be contributing to deforestation. By displacing ranching in existing agricultural areas, sugar may be adding to the pressures that send cattlemen deeper into frontier territory like the Amazon and the biologically diverse savannas known as the *cerrado*. "If alcohol is now considered a 'clean' fuel, the process of making it is very dirty," says Marcelo Pedroso Goulart, a prosecutor for the Public Ministry of São Paulo. "Especially the burning of cane and the exploitation of the cane workers."

Every biofuel also consumes crops that could be feeding a hungry globe. A recent UN report concludes that although the potential benefits are large, the biofuels boom could reduce food security and drive up food prices in a world where 25,000 people die of hunger every day, most under age five. Demand for both fuel and food is expected to more than double by mid-century, and many scientists fear that in coming decades, climate change will undermine agricultural productivity. "Agriculture should be used to stop the hunger of the people. If one person were hungry, this would be a shame," says Goulart. "There are millions who are hungry in Brazil, and this monoculture does not help."

The only way to reap the benefits of biofuels without squeezing the food supply is to take food out of the picture. Though corn kernels and cane juice are the traditional sources of ethanol, you can also make it from stalks, leaves, and even sawdust—plant by-products that are normally dumped, burned, or plowed back under. These materials are mostly cellulose, the tough chains of sugar molecules that make up plant cell walls. Breaking up those chains and fermenting the sugars could yield a cornucopia of biofuels, without competing with food crops. Biofuel visionaries picture a resurgence of deep-rooted perennial prairie grasses like switchgrass or buffalo grass, sequestering carbon in the soil, providing wildlife habitat and erosion control, and supplying a bounty of homegrown fuel.

The principle behind cellulosic ethanol is simple. Making it as cheap as gas isn't.

So far, only a few pilot plants are making ethanol from cellulose in the U.S. A small operation at the National Renewable Energy Lab (NREL) in Golden, Colorado, has been running the longest. It can convert a ton of biomass—shredded cornstalks, switchgrass, wood—into 70 gallons of ethanol in about a week. Along with cellulose and hemicellulose, these feedstocks all contain a substance called lignin. Lignin binds the cellulose molecules together, giving plants the structural strength to stand up and catch the sun. The gluey lignin also makes plant matter hard to break down, as the pulp and paper industry is well aware. "The old joke is you can make anything from lignin but money," says Andy Aden, a senior researcher on the ethanol project.

To unlock the cellulose molecules from the lignin, the feedstock is often pretreated with heat and acid. Then it's mixed with high-tech enzymes to break down the cellulose into sugars. The resulting dark brown goo, with a slightly sweet, molasses-like aroma, is fed into fermentation tanks where bacteria or yeast go to work to make the alcohol. The current process turns just 45 percent of the energy content in the biomass into alcohol, compared with an oil refinery, which extracts 85 percent of the energy in crude oil. The efficiency will have to improve for cellulosic ethanol to compete with gasoline, and researchers

are looking for better cellulose-busters. One possibility: genetically modified microbes and enzymes from the guts of termites—nature's own cellulosic energy factories.

The potential, however, is huge. Exploiting the cellulose in corn plants, rather than just the kernels, could double corn's ethanol yield; switchgrass could produce as much ethanol per acre as sugarcane. A 2005 study by the U.S. Department of Agriculture and the U.S. Department of Energy estimated that by boosting farm productivity and planting 50 million acres of fallow land with perennial grasses and fast-growing trees, the U.S. could produce 1.3 billion tons of feedstock for ethanol. Separately, NREL calculated that all that plant matter could replace more than half the transportation fuel currently burned each year. Mike Pacheco, former director of NREL's Bioenergy Center, pulls out a chart from that study. "The green line is what we think we can make on farms and from trees and switchgrass"—the equivalent of 3.5 billion barrels of oil.

Pacheco traces another line on his chart, at twice the altitude of the first. It represents the ultimate biofuels dream: enough green fuel to make the U.S. energy independent. It is where we might be, says Pacheco, if we greatly increase vehicle efficiency while churning out cellulosic ethanol, or, more tantalizing, "if we make algae work."

There is no magic-bullet fuel crop that can solve our energy woes without harming the environment, says virtually every scientist studying the issue. But most say that algae—single-celled pond scum—comes closer than any other plant because it grows in wastewater, even seawater, requiring little more than sunlight and carbon dioxide to flourish. NREL had an algae program for 17 years until it was shut down in the mid-1990s for lack of funding. This year the lab is cranking it back up again. A dozen start-up companies are also trying to convert the slimy green stuff into a viable fuel.

GreenFuel Technologies, of Cambridge, Massachusetts, is at the head of the pack. Founded by MIT chemist Isaac Berzin, the company has

Biodiesel

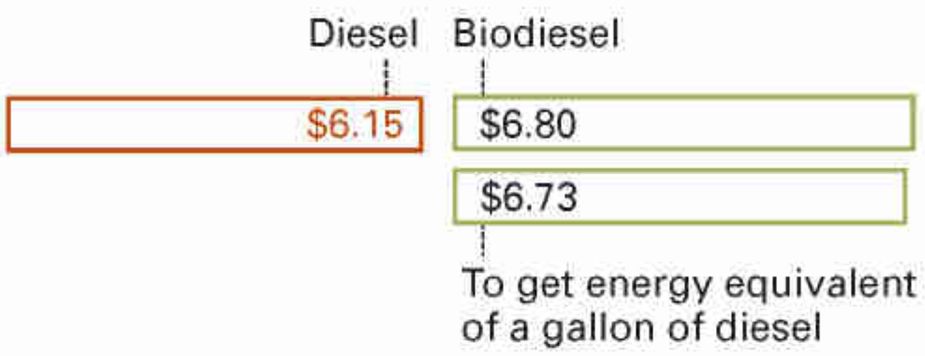
Chemically altering plant oils to make biodiesel takes less energy than distilling corn into ethanol; the fuel's main drawbacks are low yield and high cost. Germany is the world's leading producer, relying on canola oil; U.S. biodiesel comes from soybeans (right).



PRODUCTION IN GERMANY (from canola)

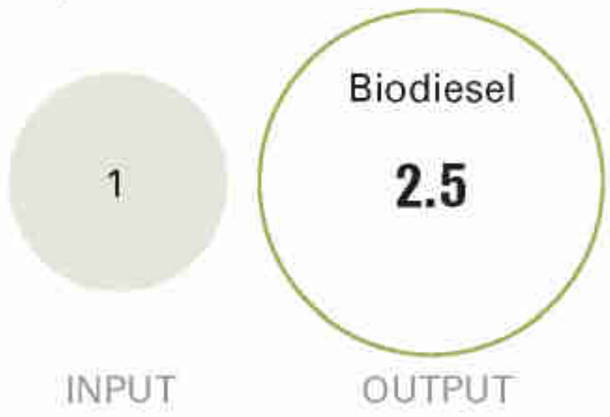
0.5 billion gallons (2005)

GERMANY RETAIL PRICE (per gallon, June 2007)

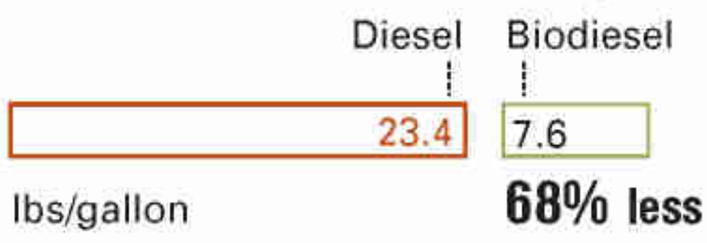


ENERGY BALANCE

Fossil-fuel energy used to make the fuel (input) compared with the energy in the fuel (output)



GREENHOUSE GAS EMISSIONS (production and use)



SOURCES: U.S. DOE; U.S. EPA; WORLDWATCH INSTITUTE





developed a process that uses algae in plastic bags to siphon carbon dioxide from the smokestack emissions of power plants. Algae not only reduce a plant's global warming gases, but also devour other pollutants. Some algae make starch, which can be processed into ethanol; others produce tiny droplets of oil that can be brewed into biodiesel or even jet fuel. Best of all, algae in the right conditions can double in mass within hours. While each acre of corn produces around 300 gallons of ethanol a year and an acre of soybeans around 60 gallons of biodiesel, each acre of algae theoretically can churn out more than 5,000 gallons of biofuel each year.

"Corn or soybeans, you harvest once a year," says Berzin. "Algae you harvest every day. And we've proved we can grow algae from Boston to Arizona." Berzin's company has partnered with Arizona Public Service, the state's largest utility, to test algae production at APS's natural-gas-burning Redhawk power plant just west of Phoenix. Algae farms around that one plant, located on 2,000 acres of bone-dry Sonoran Desert, could double the current U.S. production of biodiesel, says Berzin.

The energy farm, as GreenFuel calls it, isn't much to look at, just a cluster of shipping containers and office trailers next to a plastic greenhouse structure longer than a football field and perhaps 50 feet wide. Outside the greenhouse, rows of large plastic tubes filled with bubbling bright green liquid hang like giant slugs from hooks. After making a few calls to his boss, GreenFuel's security-conscious head of field operations, Marcus Gay, allows me to inspect this "seed farm," which grows algae for the greenhouse. Everything else is off limits. The company guards its secrets closely.

With good reason: Only perhaps a dozen people on the planet know how to grow algae in high-density systems, says Gay. Algae specialists, long near the bottom of the biology food chain, are becoming the rock stars. Two of Arizona's largest universities recently started algae programs. Their biggest challenge, as with cellulosic ethanol, is reducing the cost of algae fuel. "At the

Cellulosic ethanol

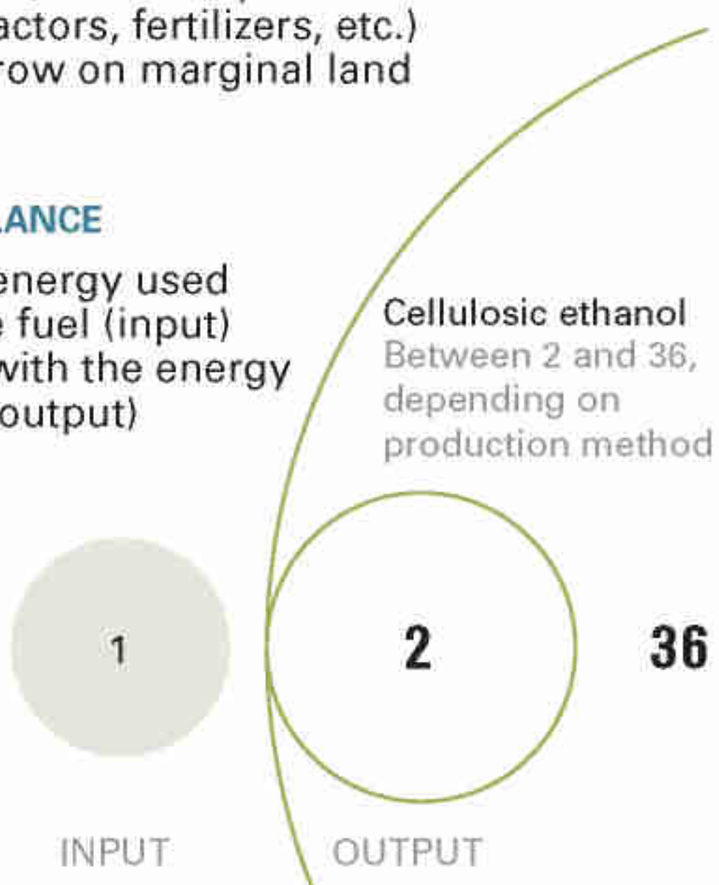
Perennial prairie grasses like switchgrass (left), grown on land unfit for other crops, could replace up to 13 percent of the world's oil consumption—if an efficient way to turn cellulosic plant matter into ethanol can be developed.

U.S. PRODUCTION
Still in development; no current production

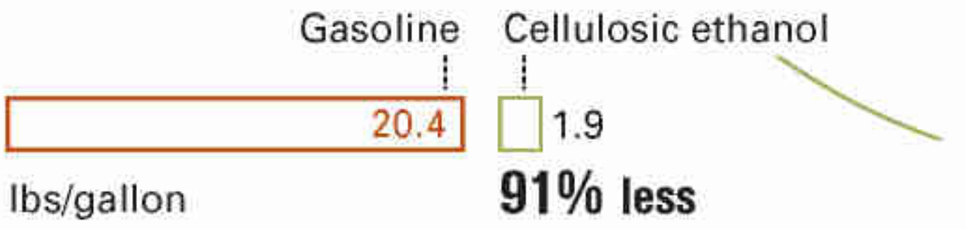
SOURCES OF CELLULOSIC ETHANOL

- Agricultural residues (leftover material from crops, such as the stalks, leaves, and husks of corn plants)
- Forestry wastes like wood chips and sawdust from lumber mills, tree bark
- Municipal solid waste (household garbage and paper products)
- Paper pulp
- Fast-growing prairie grasses, such as switchgrass, which require less energy (tractors, fertilizers, etc.) and can grow on marginal land

ENERGY BALANCE
Fossil-fuel energy used to make the fuel (input) compared with the energy in the fuel (output)



GREENHOUSE GAS EMISSIONS (production and use)



SOURCES: U.S. DOE; U.S. EPA; WORLDWATCH INSTITUTE

end of the day for this to work, this has to be cheaper than petroleum diesel," says Gay. "If we're one penny over the cost of diesel per gallon, we're sunk." (In July, rising costs and technical problems forced GreenFuel to shut down the Redhawk bioreactor temporarily.)

Hard numbers—supply, efficiency, and, most important, price at the pump—will determine the future of ethanol and biodiesel. But for now green fuels have an undeniable romance. In the garage of his office complex in downtown Phoenix, Ray Hobbs, a senior engineer for APS who is leading the company's fuel initiative, walks past a small fleet of electric cars, hybrids, even a hydrogen-powered bus. He climbs into a big diesel Ford van and turns the key. The exhaust, unlike a typical diesel's, is invisible, with just the faintest whiff of diesel smell from the algae biodiesel made at the Redhawk pilot plant. The superslick plant oil has also quieted a little of that annoying diesel rattle.

"The way I think about these things is I'm sitting in a river in a canoe," says Hobbs. "Now do I want to paddle upstream, or do I want to go with the flow? Algae is downstream, with the flow. We have processes in nature that are honed for us, that have evolved. So we can take those processes and make them faster and more efficient and harness that power. We can't wait generations to screw around with this. We have to do it now."

Hobbs says he has fielded dozens of calls from power companies interested in building an algae plant of their own to scrub emissions and help meet their renewable fuels mandate. The lure of plant fuels even seems to have reached the petroleum-rich sands of the Middle East, where the United Arab Emirates has launched a 250-million-dollar renewable energy initiative that includes biofuels—perhaps a sign that even the sheikhs now realize that the oil age won't last forever.



A Growth Industry See more images and hear author Joel K. Bourne, Jr., discuss the benefits and potential human costs of biofuels at **ngm.com/0710.**

"At the end of the day for this to work, this has to be cheaper than petroleum diesel. If we're one penny over the cost of diesel per gallon, we're sunk." MARCUS GAY, GREENFUEL



High hopes hang on bags of algae outside the Redhawk power plant near Phoenix. Researchers say the fast-growing green scum, fed by power plant exhaust, could soak up carbon dioxide while cranking out 5,000 gallons of biodiesel an acre each year—at least in theory. □

RIO NEGRO | FROM DARKNESS INTO LIGHT, A YACARE CAIMAN SLIPS ONTO A SANDBANK ALONG THIS RIVER IN SOUTHERN BRAZIL.

Through the Eyes of the Condor

AN AERIAL VISION OF LATIN AMERICA

This is the land as Simón Bolívar dreamed it,
made one by the spine of its cordillera and the
intricate vascular system of the Amazon.

BY MARIE ARANA | PHOTOGRAPHS BY ROBERT B. HAAS



PACAYA | DAWN REVEALS THE SMOLDERING FURY OF PACAYA, ONE OF GUATEMALA'S MOST ACTIVE VOLCANOES.



BELÉM | A PATCHWORK OF TIN AND TILE ROOFS HOLDS OFF THE RAINS IN THIS BRAZILIAN AMAZON PORT CITY.

The people of Latin America are children of the earth, molders of clay, movers of rock.

Since the age of the Inca, we have believed that we spring from the soil as surely as seeds—that life in this volatile home holds the promise of plenty or the shock of seismic upheaval. The earth can feed us. Or destroy us. We are at once the blessed and cursed inheritors of a fierce and bountiful land.

Perhaps that is why the Inca so loved the sun and the Maya built stairs to the skies, and conquistadores clambered up hills to thrust crucifixes into high ground. We want to be free of the earth's embrace. Sprout wings. Fly. We long to see through the eyes of the condor.

Imagine then, this native Peruvian, whose feet are most comfortable on terra firma, joining a photographer's expedition to survey her home from the air. That was the position in which I found myself one autumn day, as I hung on for dear life in the rear of a Pilatus Porter, the breast of our tiny craft beating against the current.

We flew over the Callejón de Huaylas, a verdant canyon that cuts through two mountain ranges—the majestic, snow-peaked Cordillera Blanca and the rippling, brown spine of the Cordillera Negra. This is the cradle of one of the earliest known civilizations of Peru, the Chavín, whose highly developed notions of agriculture informed the later genius of the Moche and Inca cultures. (*Qosqo*, the Inca would later call their perch in the Andes: umbilical of the world.) The Callejón is also in the stretch of mountain that boasts one of the highest peaks in all of South America, the spectacular Nevado Huascarán, whose 22,205-foot summit lords over the valley, and whose ice and snows have alternately nurtured and extinguished all life below.

Latin America is full of such paradoxes. We leap to tell visitors that our countries hold a smorgasbord of landforms—coastline, desert, jungle, mountain, marshland, archipelago—all in defined geographic spaces, and often in dramatic contiguity. The white promontories of the Andes are not far from the impenetrable canopy of the Amazon, where every November the jungle floor is deluged by floodwaters, and jaguars are forced to swim with the pink dolphins. Not until I was flying 5,000 feet above the earth did I see how close and interdependent those landforms truly are. A few minutes in the air can take you from the vernal cliffs of Lima's seaside suburbs to the windblown desert of Chan Chan, the once grand citadel of the Chimú; or from the unforgiving rock over which the conquistadores labored to the green vales of Cajamarca. All of it, interconnected. One.

For all the history that has spooled below, for all the suffering that still plagues the region, the view from above is calm and neutral—and the terrain it reveals, seamless and whole. It is, I can't help but think, Latin America as the



Great Liberator Simón Bolívar dreamed it, a vast land made one by the spine of its cordillera, by the intricate vascular system that flows from its dark Amazon heart. There are no borders in this America. No nationalities. One zone merges into another, towns and cities come and go, valleys yield to mountains, and high snows trickle down to feed an emerald forest.

Bolívar's dream of a unified region, a place where all nations would gather to form a stronger people, never came to be. He died in exile, despised and penniless, and Latin America forged ahead in all its splendid diversity. Yet Bolívar was not alone in dreaming about Latin America. It is a place, when all is said and done, built on dreams. The fearless seafaring Alacaluf of Tierra del Fuego and the Aztec of Mexico dreamed of greatness and, with considerable struggle, won it. As did the inventive Moche, the Maya, and the Inca. And then, when Spain turned its hunger westward, all Europe dreamed of what wonders it might acquire. Latin America soon became the object of wholesale fantasy. Fifteenth-century sages imagined a land populated by Pygmies, Cyclopes, fierce warrior women, and sullen, dog-faced men. They fancied a world replete with magical realities: The fountain of youth. A paradise of the senses. Gold.

Even before Columbus set sail, he worried his old copy of *Imago Mundi* and dreamed of a land unlike anything he knew. Then, in the 16th century, as the territory Columbus had chanced upon was being settled, Sir Thomas More imagined the Utopia it might become.

The dreamscapes in Robert Haas's photographs hark back to that spirit of discovery. To the force of the imagination. For, despite all the hard business of life in Latin America—despite all the realities on the ground—we are a people who long to rise, who seek the sky, who patiently await the magic. Even if it will never come. Why else would we scratch lines into the parched clay of Nasca that only a winged creature might see? Why else would we pile stone on stone at Chichén Itzá to mark the sun's passage through heaven?

At one point, as Haas and I soared through the skies, I glanced down and saw the sugar fields of Trujillo where I had played as a child, the rugged Pacific coast my brother and I had explored on horseback, the dense rain forest canopy under which my forebears had struggled against all odds to ride the Amazon until it coursed out to sea. All of it at this remove seemed oddly divorced from the sturm and drang of family history, free of the human condition. Something happens when we look on the earth in that way: Mankind becomes a mere anecdote against that staggering canvas; we see ourselves as we really are—bound to the natural world around us. Mites upon a mighty orb.

Photographs and text adapted from Robert B. Haas's book Through the Eyes of the Condor, *introduction by Marie Arana, published by National Geographic Books.*



CORDILLERA BLANCA | FINS OF STONE AND FIELDS OF SNOW SURROUND PARÓN GLACIER IN WESTERN PERU.

LIGHTHOUSE REEF | DARK LENS ON INNER SPACE, A SINKHOLE IN BELIZE'S BLUE HOLE NATURAL MONUMENT PLUNGES 410 FEET.



SALAR DE UYUNI | ARID WATERWAYS RIBBON THE WORLD'S LARGEST SALT FLAT HIGH IN SOUTHWESTERN BOLIVIA.



RIO NEGRO | THIS TRIBUTARY OF THE AMAZON REFLECTS SKY AND CLOUDS BESIDE A CEMETERY DUG INTO ITS BANK.





GUAYAQUIL | FLAGS FLUTTER LIKE CONFETTI OVER PENS AT A SHRIMP FARM IN ECUADOR, PROTECTING THE CROP FROM BIRDS.



LAKE TITICACA | SLIVERS OF CROP FIELDS IN PERU PIERCE THE LAKE BED, SOAKING UP NUTRIENTS LEFT BY RETREATING WATER.



YUCATÁN PENINSULA | A SHIFTING FLOCK OF FLAMINGOS ASSUMES A WHIMSICAL SHAPE IN THE GULF OF MEXICO. □



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HOW ANIMALS AND HUMANS EXCHANGE DISEASE

Deadly Contact

By DAVID QUAMMEN
NATIONAL GEOGRAPHIC CONTRIBUTING WRITER

Photographs by LYNN JOHNSON

Placid under sedation, a juvenile rhesus macaque yields biological samples that could show him to be infected with human diseases such as tuberculosis or measles. Similarly, primates can pass pathogens to humans—potentially touching off pandemics.





RESERVOIRS

On her way to market in a village in the Democratic Republic of the Congo, a child carries a basket containing a Gambian rat, the arm of a monkey—and perhaps a fatal illness. Monkeypox lurks in African wild game, or bush meat: Rodents are a likely reservoir, carrying the virus without symptoms, while monkeys can die of it. So do people, and the human death toll is one of many mysteries about the disease. It is now known to be endemic to this region, says Anne Rimoin, a pioneering UCLA monkeypox researcher.



OUT OF NOWHERE *In 1994 in Australia, an unknown disease erupted in the Brisbane suburb of Hendra. It killed horribly and burned out quickly, but the aftereffects of the Hendra virus linger like a nightmare for Ray Unwin (above). "I can't get the tiredness out of my body," the stable foreman says. Hendra was finally traced to bats in a local fruit tree, but not before claiming 13 horses and a colleague of Unwin's.*

In September 1994, a violent disease erupted among racehorses in a suburb of Brisbane, Australia. The place, called Hendra, was a quiet old neighborhood filled with racecourses, stables, newsstands that sell tip sheets, corner cafés with names like The Feed Bin, and racing people. The first victim was a pregnant mare named Drama Series, who started showing symptoms in an outlying pasture and was brought back to her trainer's stable for doctoring, where she only got worse. Three people worked to save her—the trainer himself, his stable foreman, and a veterinarian. Within two days Drama Series died, leaving the cause of her trouble uncertain. Had she been bitten by a snake? Had she eaten some poisonous weeds out in that scrubby, derelict meadow? Those hypotheses were eliminated two weeks later, when most of her stablemates fell ill. This wasn't snakebite or toxic fodder. It was something contagious.

The other horses suffered fever, respiratory distress, facial swelling, and clumsiness; in some, bloody froth came from the nostrils and mouth. Despite heroic efforts by the veterinarian, 12 more animals died within days. Meanwhile the trainer himself got sick; so did the stable foreman. The vet, who was following cautionary procedures but working amid the same mad circumstances, stayed healthy. After a few days in a hospital, the trainer died. His kidneys had failed and he couldn't breathe. The stable foreman, a bighearted man named Ray Unwin, who had merely gone home to endure his fever in private, survived. He and the veterinarian told me their stories when I found them in Hendra last year. Ray Unwin is a middle-aged working bloke with a sandy red ponytail and a weary sadness in his eyes, who professed that he wasn't a "whinger" (complainer) but said his health has been "crook" (not right) since it happened.

Laboratory analysis revealed that the horses and the men were infected by a previously unknown virus. At first the lab people called it equine morbillivirus, meaning a horse virus closely related to measles. Later, as its uniqueness became better appreciated, it was renamed after the place itself: Hendra. The veterinarian, a tall, gentle fellow named Peter Reid, told me that "the speed with which it went through those horses was unbelievable." At the height of the crisis, seven animals had succumbed to ugly deaths or required euthanasia within just 12 hours. One of them died thrashing and gasping so desperately that Reid couldn't get close enough to give it the merciful needle. "I'd never seen a virus do anything like that before," he said. A man of understatement, he recalled it as "a pretty traumatic time."

Identifying the new virus was only step one in solving the immediate mystery of Hendra, let alone understanding the case in a wider context. Step two involved tracking that virus to its hiding place. Where did the thing exist when it wasn't killing horses and people? Step three entailed asking a further cluster of questions: How did it emerge from its secret refuge, and why here, and why now?

After our first conversation, Peter Reid drove me out to the site where Drama Series took sick.

When a pathogen leaps

from some nonhuman animal into a person, and succeeds there in making trouble, the result is what's known as a zoonosis. It's a word of the future.

Tract houses on prim lanes have been built over the original pasture. Not much of the old landscape remains. But toward the end of one street is a circle, called Calliope Circuit, in the middle of which stands a single mature tree, a native fig, beneath which the mare would have found shelter from eastern Australia's fierce subtropical sun.

"That's it," Reid said. "That's the bloody tree." That's where the bats gathered, he meant.

Infectious disease is all around us. Infectious disease is a kind of natural mortar binding one creature to another, one species to another, within the elaborate edifices we call ecosystems. It's one of the basic processes that ecologists study, including also predation, competition, and photosynthesis. Predators are relatively big beasts that eat their prey from outside. Pathogens (disease-causing agents, such as viruses) are relatively small beasts that eat their prey from within. Although infectious disease can seem grisly and dreadful, under ordinary conditions it's every bit as natural as what lions do to wildebeests, zebras, and gazelles.

But conditions aren't always ordinary.

Just as predators have their accustomed prey species, their favored targets, so do pathogens.

David Quammen won a National Magazine Award for his essay, "Was Darwin Wrong?" in the November 2004 issue. Lynn Johnson, a frequent contributor, photographed the October 2005 story "Tracking the Next Killer Flu."

And just as a lion might occasionally depart from its normal behavior—to kill a cow instead of a wildebeest, a human instead of a zebra—so can a pathogen shift to a new target. Accidents happen. Aberrations occur. Circumstances change and, with them, opportunities and exigencies also change. When a pathogen leaps from some nonhuman animal into a person, and succeeds there in making trouble, the result is what's known as a zoonosis.

The word zoonosis is unfamiliar to most people. But it helps clarify the biological reality behind the scary headlines about bird flu, SARS, other forms of nasty new disease, and the threat of a coming pandemic. It says something essential about the origin of HIV. It's a word of the future, destined for heavy use in the 21st century.

Ebola is a zoonosis. So is bubonic plague. So are yellow fever, monkeypox, bovine tuberculosis, Lyme disease, West Nile fever, Marburg, many strains of influenza, rabies, hantavirus pulmonary syndrome, and a strange new affliction called Nipah, which kills pigs and pig farmers in Malaysia. Each of them reflects the action of a pathogen that can cross to people from other species. This form of interspecies leap is common, not rare; about 60 percent of all human infectious diseases currently known are shared between animals and humans. Some of those—notably rabies—are widespread and famously lethal, still killing humans by the thousands despite centuries of effort at coping with their effects, concerted international attempts to eradicate or control them, and a clear scientific understanding of how they work. Others are new and inexplicably sporadic, claiming a few victims (as Hendra did) or a few hundred in this place or that, and then disappearing for years.

Smallpox, to take one counterexample, is not a zoonosis. It's caused by a virus that infects *Homo sapiens* and, in very exceptional cases, certain nonhuman primates, but not horses or rats or other species. That helps explain why the World Health Organization's global campaign

THE HOST *Fruit bats, such as this little red flying fox, likely have carried the Hendra virus for millennia. No outbreaks were observed until the 1990s: One theory is that habitat loss has forced bats into closer contact with humans. Fruit bats are under scrutiny as reservoirs for several other deadly diseases, including Ebola, Nipah, and SARS.*



PTEROPUS SCAPULATUS

to eradicate the disease was, as of 1979, successful. Smallpox could be eradicated because its virus, lacking ability to reside virtually anywhere other than in humans, couldn't hide. Zoonotic pathogens can hide.

Monkeypox, though closely related to smallpox, differs in two crucial ways—its propensity to afflict monkeys as well as humans, and the ability of its virus to exist in still other species, some of which are so far unidentified. Yellow fever, also infectious to both monkeys and humans, and caused by a virus that hides in several species of mosquito, will probably never be eradicated. The Lyme disease perpetrator, a type of bacterium, hides effectively in white-footed mice and other small mammals. These pathogens aren't consciously hiding, of course. For their purposes, such behavior merely constitutes a strategy of indirect transmission or inconspicuous survival.

The least conspicuous strategy of all is to lurk within what's called a reservoir host, a species that carries the pathogen while suffering little or no symptomatic illness. When a disease seems to disappear between outbreaks (again, as Hendra did after the 1994 carnage), its causal pathogen may indeed have died out, at least from the region—but then again, maybe not. Maybe it's still lingering nearby, all around, within some reservoir host. A rodent? A bird? A butterfly? Possibly a bat? To reside undetected within a reservoir host is probably easiest wherever biological diversity is high and the ecosystem is relatively undisturbed. The converse is also true: Ecological disturbance causes diseases to emerge. Shake a tree, and things fall out.

Some months after the deaths in Australia, a scientific sleuth named Hume Field started looking for Hendra's reservoir host. Field was a veterinarian who, having practiced privately for years, had decided to pursue a doctorate in veterinary epidemiology. The search for the reservoir became his dissertation project. He gathered blood samples from 16 different species, a whole menagerie of suspects, including marsupials, birds, rodents, amphibians, and insects. He sent the samples to a laboratory for screening, which yielded no evidence whatsoever of Hendra.

Then he took blood from *Pteropus alecto*, a species of fruit bat, big as a crow and commonly known as the black flying fox. Bingo: The lab team found molecular traces left by Hendra virus. Further sampling produced similar evidence from three other species of flying foxes, all native to the forests of Queensland (the state encompassing Brisbane) and other wooded regions of Australia. Field and his collaborators had established that bats were the reservoir. Detecting molecular traces is less definitive than finding particles of live virus, but within one female bat they did find that form of evidence also.

The lab work suggested that Hendra was an old virus, having probably existed within its reservoir host for thousands of years. Despite its age, it had never before—so far as historical records and human memory could say, anyway—caused disease in humans. What accounts for its emergence in 1994? Well, bad luck for Drama Series and those who knew her. Bats came to eat the figs in that solitary tree, and the poor mare, seeking shade, grazing too carelessly, evidently swallowed not just grass but also something of what they dropped, such as fruit pulp, feces, urine, afterbirth, and virus.

But there had to be a broader answer, too. Why did Hendra emerge in 1994, not decades or centuries earlier? Something was different. Some sort of change, or combination of changes, must have caused the virus to be transferred from its reservoir host into other species.

The fancy name for such transfer is spillover. Maybe the virus needed horses (which only reached Australia with European colonists), as distinct from kangaroos (which have been eating grass beneath Australian fig trees for millennia), to mediate its spillover from the reservoir. Maybe bats, figs, horses, and humans had

simply never been brought so closely together. Hume Field is currently a research scientist at the Animal Research Institute of Queensland's Department of Primary Industries, in Brisbane. When I spoke with him at his office there, he raised the issue of "what might be happening now that hasn't happened before." Part of the answer is that human destruction of eucalyptus forests has disrupted the customary feeding and roosting habits of some flying foxes, forcing them toward shady suburbs, orchards, botanical gardens, city parks, and closer proximity to people.

But proximity is one thing; spilling virus into horses is another. "How does transmission occur?" Field wondered aloud, at the end of our long conversation. "Well, we still don't know."

Nearly all zoonotic diseases result from infection by one of six kinds of pathogen: viruses, bacteria, protozoans, prions, fungi, and worms. Mad cow disease is caused by a prion, a weirdly folded protein molecule that triggers weird folding in other molecules, like Kurt Vonnegut's infectious form of water, ice-nine, in his great early novel *Cat's Cradle*. Sleeping sickness is a protozoan infection, carried by tsetse flies between wild and domestic mammals and people on the landscapes of sub-Saharan Africa. Anthrax is a bacterium that can live dormant in soil for years and then, when scuffed out, infect humans by way of cattle. Toxocariasis is a mild zoonosis caused by roundworms; you can get it from your dog. But fortunately, like your dog, you can be wormed.

Viruses are the most problematic. They evolve quickly, they are unaffected by antibiotics, they can be elusive, they can be versatile, they can inflict extremely high rates of mortality, and they are fiendishly simple, at least relative to other living or quasi-living creatures. Hanta, SARS, monkeypox, rabies, Ebola, West Nile, Machupo, dengue, yellow fever, Junin, Nipah, Hendra, influenza, and HIV are all viruses. The

Disease can go both ways.

Measles, polio, scabies, influenza, tuberculosis, and other human diseases are considered threats to nonhuman primates. The label for those infections is anthropozoonotic.

full list is much longer. There is a thing known by the vivid name simian foamy virus (SFV) that infects monkeys and humans in Asia by way of venues (such as Buddhist and Hindu temples) where people and half-tame macaques come into close contact. Some of the people visiting those temples, feeding handouts to those macaques, exposing themselves to SFV, are international tourists. "Viruses have no locomotion," according to the eminent virologist Stephen S. Morse, "yet many of them have traveled around the world." They can't run, they can't walk, they can't swim, they can't crawl. They ride.

About the same time as the Hendra outbreak near Brisbane, another spillover occurred, this one in central Africa. Along the upper Ivindo River in northeastern Gabon, near the border with the Republic of the Congo, lies a small village called Mayibout II. In early February 1996, 18 people there became suddenly sick after they participated in the butchering and eating of a chimpanzee. Their symptoms included fever, headache, vomiting, bleeding in the eyes, bleeding from the gums, hiccuping, and bloody diarrhea. All 18 were evacuated downriver to a regional hospital, where four soon died. The bodies were returned to Mayibout II and buried, with no special precautions; a fifth victim escaped from the hospital, went back to the village, and died there. Secondary cases occurred among people infected by loved ones or friends,





HARD SCIENCE

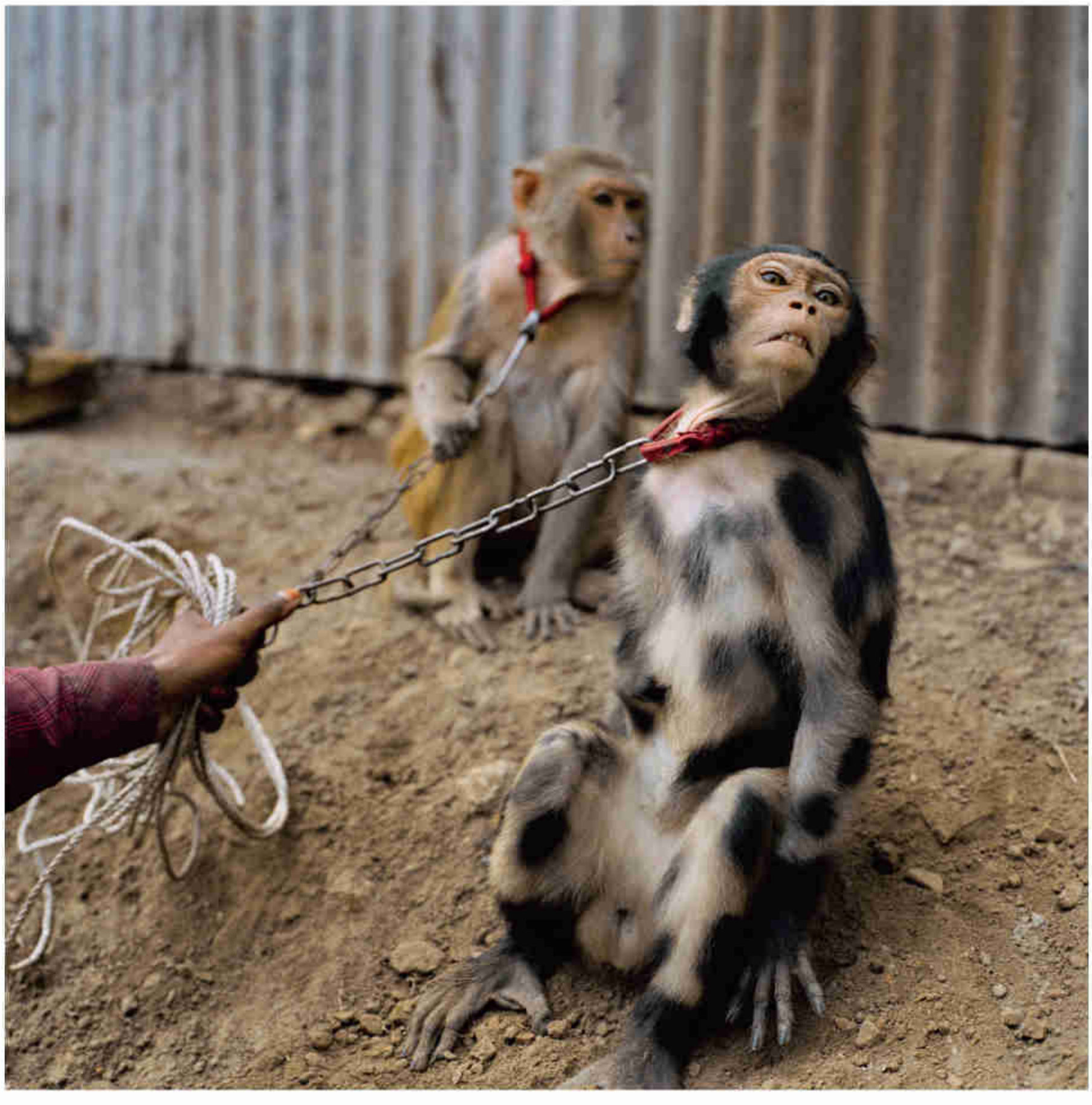
Syringe in hand, Lisa Jones-Engel moves quickly to sedate trapped rhesus macaques in Dhamrai, Bangladesh, while on the roof behind her, monkey onlookers screech alarm. The University of Washington researcher's team is documenting two-way disease transmission between humans and monkeys, a process that can spawn new diseases.

or in handling the dead bodies. Eventually 31 people got sick, of whom 21 died—a mortality rate of 68 percent.

Those facts and numbers were collected by a team of medical researchers, some Gabonese, some French, who reached Mayibout II during the outbreak. Among them was a Frenchman named Eric M. Leroy, based at the Centre International de Recherches Médicales de Franceville (CIRMF), in Franceville, Gabon. Leroy and his colleagues identified the disease as Ebola hemorrhagic fever and deduced that the butchered chimpanzee had been infected with Ebola virus. Their investigation also revealed that the chimp hadn't been killed by village hunters; it had been found dead in the forest and scavenged.

Four years later, I sat at a campfire near the upper Ivindo River with a group of local men working as forest crew for a long overland trek. (See "The Green Abyss: Megatransect, Part II," March 2001.) The men, mostly Bantu, had been walking for weeks before I joined them on the march. Their job involved carrying heavy bags through the jungle and building a new camp every night for the Wildlife Conservation Society biologist J. Michael Fay, whose extraordinary grit and sense of mission drove the enterprise forward. This particular day had been a relatively easy one—no swamps crossed, no charging elephants—which allowed for a relaxed, confiding atmosphere at the evening fire. I learned that two of the men, Thony M'Both and Sophiano Etouck, had been present in Mayibout II when Ebola struck the village. M'Both, slim in build, older, and more voluble than the others, was willing to talk about it. He spoke in French while Etouck, a shy man with wide shoulders, an earnest scowl, and a goatee, sat silent. Etouck's own family had been devastated by the disease. He had held one of his dying nieces in his arms, while an IV drip in her wrist became clogged, swelled her hand, and exploded, covering him with her blood. Yet Etouck himself never got sick. Nor did I, said M'Both. The cause of the illnesses was a matter of confusion and fearful rumor. M'Both suspected that French soldiers, visiting nearby, had killed the chimpanzee with some sort of chemical weapon and carelessly left it to poison unsuspecting people. But whatever the cause, whatever the contaminant, his fellow villagers had learned their lesson. To this day, he said, no one in Mayibout II eats chimpanzee.





CLOSE CONTACT *Ritual slaughter with flowing blood is repeated countless times across the Bangladesh capital, Dhaka, on the feast of Id al-Adha. Muslim faithful share meat with the poor, but the tradition carries risk. The country imports a million or more cows for the feast, making effective monitoring for bovine TB or other diseases impossible. Performing monkeys, including one decorated with paint (above, at right), mingle—and can share viruses—with people.*

Once the contact has occurred and the pathogen has crossed, two factors contribute to the possibility of cataclysmic consequences: the sheer abundance of humans and the speed of our travel from one place to another.

Amid the chaos and sorrow of the outbreak, M'Both told me, he and Etouck had seen something bizarre: 13 gorillas, all dead, lying in the forest. That image, of 13 gorilla carcasses strewn on the leaf litter, is lurid but plausible. Subsequent research has confirmed that gorillas are susceptible to Ebola. Being social creatures, they could easily pass the infection among group members by mutual grooming, infant care, or trying to rouse their sick or their dead.

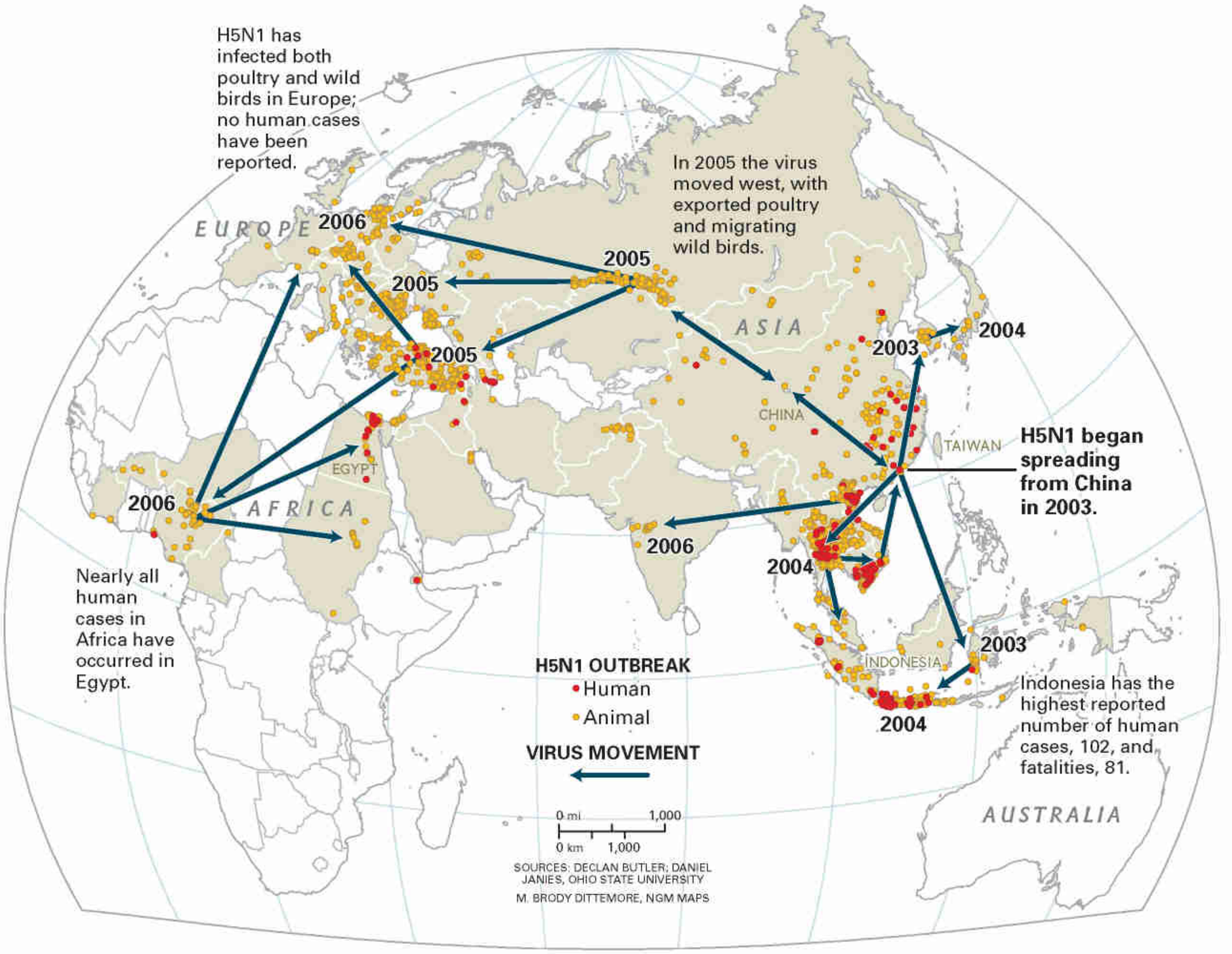
In the years since 1996, other outbreaks of Ebola have struck both people and great apes (chimps as well as gorillas) within the region surrounding Mayibout II. One area hit hard lies along the Mambili River, just over the border in northwestern Congo, another zone of dense forest encompassing several villages, a national park, and a gorilla sanctuary known as Lossi. Mike Fay and I walked through that area also, in March 2000, during one of my earlier stints with his expedition. At the time, gorillas were abundant within the Mambili drainage. But in 2002 a team of researchers at Lossi began finding gorilla carcasses, some of which tested positive for Ebola. Within a few months, 91 percent of the individual gorillas they'd been studying (130 of 143 animals) had vanished, and most of those were presumably dead. Extrapolating from confirmed deaths and disappearances to overall toll throughout their study area, the researchers published a paper in *Science* under the headline: "Ebola Outbreak Killed 5000 Gorillas."

Last autumn I returned to the Mambili River with a team led by William B. (Billy) Karesh, director of the Wildlife Conservation Society's Field Veterinary Program and an authority on zoonotic diseases. Karesh's goal was to tranquilize a few surviving gorillas, take blood samples, and see whether those animals showed exposure to Ebola. Along with an expert tracker named Prosper Balo, plus other veterinarians and guides, we spent eight days searching the forest. Prosper Balo had worked at Lossi. With his guidance, we staked out a *bai* (a natural clearing) full of succulent vegetation, previously known for the dozens of gorillas that came there daily to eat and relax. Billy Karesh himself had visited the same area in 2000, before Ebola struck, to gather baseline data on gorilla health. "Every day," he told me, "every bai had at least a family group." He'd been successful on that trip—the only person ever to tranquilize-dart lowland gorillas. This time things were different. So far as we could see, there were scarcely *any* survivors. We caught glimpses of just two gorillas. The others had either dispersed to parts unknown, or they were . . . dead? Anyway, once gorillas had been abundant hereabouts, and now they were gone.

The virus seemed to be gone, too. But we knew it was only hiding.

Hiding where? For a decade, the identity of Ebola's reservoir host was one of the darkest mysteries in the world of disease science. Several sets of researchers were trying to solve it. Then, two years ago, Eric Leroy and some colleagues announced in the journal *Nature:* "We find evidence of asymptomatic infection by Ebola virus in three species of fruit bat, indicating that these animals may be acting as a reservoir for this deadly virus." Leroy's group hadn't captured any live virus, but they had established—with positive results from several kinds of molecular tests—that Ebola had passed through at least a few of the bats examined.

Leroy himself wants stronger evidence. "We continue to catch bats—to try to isolate virus



MARCH OF THE BIRD FLU *The avian influenza strain H5N1 is the world's top pandemic threat. Starting in China, in 2003 it began spreading through other parts of Asia and by 2006 had shown up in Europe and Africa. Experts fear that H5N1, which has killed fewer than 200 people, may mutate to a virulent form able to wipe out millions.*

from their organs," he said late last year, when I visited him in Franceville. Identifying the reservoir host with certitude, though, would still leave other questions unanswered.

For instance, how does Ebola emerge from that reservoir? "We don't know if there's direct transmission from bats to humans," Leroy said. "We only know there is direct transmission from dead great apes to humans." And how has the virus evolved, producing four distinct strains? Why is the Ebola-Zaire strain, the one found in Gabon and Congo, so highly lethal (about 80 percent mortality) to people? What is its natural life cycle? What's the spillover mechanism into gorillas and chimps? How does the virus affect the human immune system? How does it find its way into humans at all? Ebola is difficult to study, Leroy explained, because of the character of the disease. It strikes rarely, it progresses quickly, it kills or it doesn't kill within just a few days, it affects relatively few people in each outbreak, and those people generally live in remote, forested areas, far from research hospitals or medical institutes; then it exhausts itself locally or is successfully stanched, and disappears back into the forest, like a hit-and-run force of guerrilla warriors. "There is nothing to do," Leroy said, with the perplexity of a patient man. He meant, nothing to do except keep trying, keep working in the lab, keep responding to outbreaks when they occur. No one can predict where Ebola might next appear. "The virus seems to decide for itself."



RISKS FROM PETS *Some two million reptiles are imported yearly to the U.S.—each a potential carrier for disease. An African sulcata tortoise, abandoned by its owner, lumbers past Susan Tellem (above) of American Tortoise Rescue in Malibu, California. Tortoises and turtles, like other reptiles, can harbor salmonella bacteria, a threat to children. Mireya Zellner, three, delights in a snake's scales at a reptile show in White Plains, New York, where some dealers post warning signs.*



LASTING PAIN *An unnoticed bite in 2003 began Coloradan Tom Weber's ordeal with West Nile fever, which killed 63 in the state that year. West Nile is a bird disease that mosquitoes pass to humans. Weber spent agonizing months on a respirator, living for his sons. He was left with ongoing ailments—and a taped news segment for them.*



Hendra and Ebola are part of a much larger pattern: the recent emergence of new zoonotic diseases, variously lethal and horrific, more than a few of which seem to be associated with bats. Another part of the pattern is human-caused disruption of wild landscape. Nipah came next.

In September 1998, a pork seller in peninsular Malaysia checked into a hospital with some sort of brain inflammation and died. Around the same time, a number of pig-farm workers came down with similar symptoms, bad fever leading to coma; several of them also died. Pigs in the area meanwhile suffered an illness of their own (or what seemed their own), coughing and wheezing, keeling over dead. The pig disease was taken to be classical swine fever. The human deaths were attributed to Japanese encephalitis. But within a few months, scientists showed that both the pigs and the people had been infected with the same virus, a new one, first isolated from a patient whose home village was called Sungai Nipah. The virus was highly contagious from pig to pig, but not from person to person. It spread elsewhere in Malaysia, and even to Singapore, with shipments of live pigs, infecting people who came in contact with the sick animals or their meat. Within seven months, the outbreak had caused 265 human cases, 105 human deaths, and led to the culling of 1.1 million pigs.

The molecular profile of this new virus suggested a close kinship with Hendra. That provided a clue. Not long afterward, researchers found Nipah living sedately in a reservoir host: *Pteropus hypomelanus,* another species of fruit bat. They also noted that fruit bats, deprived of habitat elsewhere, had been congregating in orchards near the pig farms.

And then there was SARS. It came out of southeastern China in early 2003, spreading readily from person to person, traveling as fast as airplanes, killing 774 humans in nine countries and scaring people all over the world. A quick bit of research pointed suspicion at the masked palm civet, a medium-size mammal often sold in Chinese markets for its meat, as the reservoir of SARS. That suspicion was discounted, though, after experiments showed that masked palm civets themselves suffer symptomatic SARS. Then a group of scientists led by Wendong Li, of the Chinese Academy of Sciences, announced that they had found reservoirs hosting a virus very similar to the one that caused the SARS outbreak: horseshoe bats of the genus *Rhinolophus.*

Viruses evolve quickly, they are unaffected by antibiotics, they can be elusive, they can be versatile, they can inflict extremely high rates of mortality, and they are fiendishly simple.

There's more. Australian bat lyssavirus, a newly identified virus closely related to rabies, has killed at least two people with rabies-like symptoms after the victims were bitten by bats. Menangle and Tioman are also bat-carried viruses, of the same family as Hendra, that scientists are watching carefully. Rabies itself and rabies-like viruses, found in bat reservoirs around the world, are still probably the most lethal of all viral pathogens if untreated—with nearly 100 percent mortality among humans. In northern Peru, last autumn, 11 children from native communities along the Amazon headwaters died from rabies contracted when they were nipped by vampire bats.

At this point, you're entitled to ask: Damn, what is it about bats?

I asked that myself, in conversation with Charles Rupprecht, a virologist and veterinarian who leads the rabies section at the Centers for Disease Control and Prevention, in Atlanta. Rupprecht recited a list of factors that make this order of mammals, the Chiroptera, ideal candidates to host a variety of dangerous viruses.





DEPOPULATED

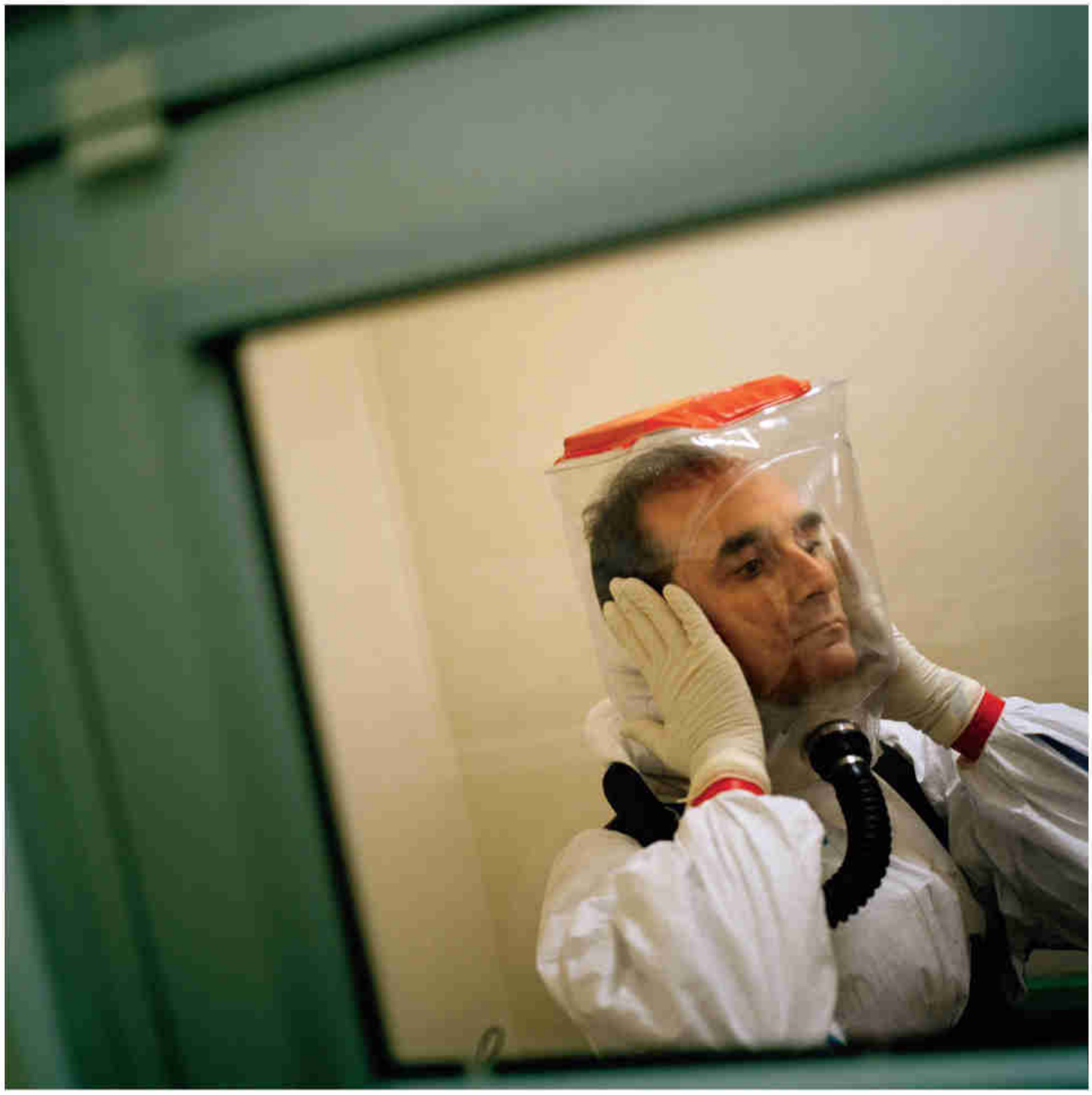
In the Republic of the Congo, William Karesh, a veterinarian with the Wildlife Conservation Society, waits in vain to tranquilize lowland gorillas for study in an area that teemed with them several years ago. The prime suspect is Ebola, which has killed thousands of gorillas in Congo and Gabon. "There's an eerie feeling of absence after an outbreak—like death has walked through the forest," Karesh says. His tracker, Prosper Balo, watches for gorillas.

Some bats roost in huge colonies, snuggled intimately together; they give birth to only a few young, and therefore nurture those young dotingly; they have long life spans, especially for small mammals; they are old, too, in evolutionary terms; they encompass a great diversity of species, roughly 20 percent of all mammals; they fly, and therefore they get around the world nicely, finding places and ways to sustain themselves on nearly every landmass except Antarctica. Add to those traits the fact that, being nocturnal and airborne, they're hard to study. "Bats really are the undiscovered country," Rupprecht said. His point—the point of a rabies biologist who happens to like bats—is that they aren't sinister and, if they seem to harbor an undue variety of nightmare diseases, it's probably because they are so various and so poorly known.

Another informed view came from Xavier Pourrut, a research veterinarian based at CIRMF in Gabon. His job involves capturing and taking blood samples from bats near Ebola outbreaks so that Eric Leroy can study their serum for evidence of the virus. "Bats represent an ancient lineage of mammals," Pourrut told me, and like Rupprecht he sees them with a biologist's appreciation. The thing to remember, he said, is that their flight powers give them great range of access, not just horizontally to places around the world, but vertically within the forest. That potentially puts them in contact not just with the fruits or the insects on which they feed, and the treetops from which they dangle, but also with an inordinate number of other species, from the canopy to the ground, including rodents, monkeys, carnivores, birds, snakes, chimpanzees, gorillas, and people.

Contact is crucial. Close contact between two species represents an opportunity for a pathogen to expand its horizons and possibilities. The pathogen may be well adapted to its quiet, secure life within a reservoir host; spilling over into a new species presents a chance, at some risk, of vastly increasing its abundance and its geographic reach. The risk is that, by killing the new host too quickly, before getting itself transmitted onward, the pathogen will come to a dead end. But evolutionary theory suggests that some pathogens, on some occasions, will accept that risk in exchange for the chance of a big payoff.





SURVIVORS *Ebola spared Balo (left, at center), Karesh's tracker in the Republic of the Congo, but it cut like a scythe through his life. His wife's siblings died, so he cares for their children as well as his—14 in all. The Ebola deaths of gorillas he'd worked with broke his heart and ended his career habituating the animals. Virologist Eric Leroy (above, in his lab at the International Center for Medical Research in Gabon) is often the first to investigate an outbreak. His research points to fruit bats as an Ebola reservoir.*

Long-term survival is only one form of evolutionary success. Gross abundance and broad distribution is another.

Think of tortoises and rats. Tortoises tend to live by a conservative strategy, remaining within their preferred habitat and reproducing slowly. Rats tend to be opportunists, fanning out, traveling across land and sea as stowaways, arriving in new places and reproducing fast. Similarly, pathogens may differ in their degree of adventurousness. Spillover from a reservoir host isn't necessarily an accident, always leading to the dead end. It may be a strategy, leading to evolutionary success. Simian immunodeficiency virus (SIV) achieved that sort of success when it spilled over from one subspecies of chimpanzee into humans, probably in west-central Africa, and became HIV-1.

Close contact between humans and other species can occur in various ways: through killing and eating of wild animals (as in Mayibout II), through caregiving to domestic animals (as in Hendra), through fondling of pets (as with monkeypox, brought into the American pet trade by way of imported African rodents), through taming enticements (feeding bananas to the monkeys at a Balinese temple), through intensive animal husbandry combined with habitat destruction (as on Malaysian pig farms), and through any other sort of disruptive penetration of humans into wild landscape—of which, needless to say, there's plenty happening around the world. Once the contact has occurred and the pathogen has crossed over, two other factors contribute to the possibility of cataclysmic consequences: the sheer abundance of humans on Earth, all available for infection, and the speed of our travel from one place to another. When a bad new disease catches hold, one that manages to be transmissible from person to person by a handshake, a kiss, or a sneeze, it might easily circle the world and kill millions of people before medical science can find a way to control it.

But our safety, our health, isn't the only issue. Another thing worth remembering is that disease can go both ways: from humans to other species as well as from them to us. Measles, polio, scabies, influenza, tuberculosis, and other human diseases are considered threats to nonhuman primates. The label for those infections is anthropozoonotic. Any of them might be



DANGEROUS FOOD

A butchered monkey at a market in the Democratic Republic of the Congo has been partially cooked. Such bush meat is the only source of animal protein in some impoverished parts of sub-Saharan Africa. If this monkey—or any of the many animals these women handle in a communal butchering area on a typical day—carried a zoonotic disease, many people would be exposed.



EMERGENCE *Medics in the Democratic Republic of the Congo found Norbert Lohalo-Nkoy dehydrated, his throat clogged with monkeypox pustules. An IV drip revived him, but he later died from complications of the disease. Scientists don't understand precisely how the virus spreads—a dangerous gap in knowledge.*



carried by a tourist, a researcher, or a local person, with potentially devastating impacts on a tiny, isolated population of great apes with a relatively small gene pool, such as the mountain gorillas of Rwanda or the chimps of Gombe.

That's why Billy Karesh and his colleagues at the Wildlife Conservation Society label their program with the slogan "One World, One Health." The guiding principles come from ecology, of which human and veterinarian medicine are merely subdisciplines. "It's not about wildlife health or about human health or about livestock health," he told me. "There's really just one health"—the health and balance of ecosystems throughout the planet.

"It's not about wildlife health or about human health or about livestock health," William Karesh said. "There's really just one health"—the health and balance of ecosystems throughout the planet.

After our fruitless stakeout along the Mambili River, in northwestern Congo, Karesh and I and Prosper Balo, along with other members of the team, traveled three hours downstream by pirogue. From there we drove a dirt road to a town called Mbomo, center point of an area where Ebola had killed 128 people during the same outbreak that struck gorillas at Lossi. We stopped at a little hospital, beside which stood a sign, painted in stark red letters:

ATTENTION EBOLA
NE TOUCHONS JAMAIS
NE MANIPULONS JAMAIS
LES ANIMAUX TROUVES
MORTS EN FORET

(Don't ever touch dead animals found in the forest.)

Mbomo was Balo's hometown. Visiting his house, we met his wife, Estelle, and some of his many children. We learned that Estelle's sister, two brothers, and another close relative all died of Ebola in 2003, and that Estelle herself was shunned by townspeople because of her association with the disease. No one would sell food to her. No one would touch her money. She had to hide in the forest. She would have died herself, Balo said, if he hadn't taught her the precautions he'd learned from Eric Leroy and the other scientists for whom he'd worked during the outbreak—sterilize everything with bleach, wash your hands, and don't touch corpses. But now the bad time was past and, with Balo's arm around her, Estelle was a smiling, healthy young woman.

Balo remembered the outbreak in his own way, mourning Estelle's losses and some of a different sort. He showed us a book, a botanical field guide, on the endpapers of which he had written a list of names: Apollo, Cassandra, Afrodita, and almost 20 others. They were gorillas, an entire group that he had known well, that he had tracked daily and observed lovingly at Lossi. Cassandra was his favorite, Balo said. Apollo was the silverback. "*Sont tous disparus en deux-mille trois,*" he said. All of them, gone in the 2003 outbreak. He'd lost his gorilla family, and also members of his own family. It was very hard, Balo said.

For a long time he stood holding the book, opened for us to see those names. He comprehended emotionally what the scientists know from their data: That we—people and gorillas, horses and pigs and bats, monkeys and rats and mosquitoes and viruses—are all in this together. □

Trading Diseases Photographer Lynn Johnson talks about the hazards of ever closer ties between humans and animals at **ngm.com/0710.**

In 1984, Bruce McCandless II became the first person to walk untethered in space. His jet-pack-powered stroll near the shuttle *Challenger* was one milestone in humanity's journey into space—an adventure that began 50 years ago this month.

NASA





Space The Next Generation



THE SPACE STATION: THEN AND NOW

In the early 1950s, a wheel-shaped outpost in space was just an artist's dream (above). But the passion to build a space station ran high. It "could be either the greatest force for peace ever devised, or one of the most terrible weapons of war—depending on who makes and controls it," said Wernher von Braun, the famed rocket scientist, in 1952. Today, the International Space Station (ISS, at right) is still being assembled in stages, with parts delivered periodically by U.S. space shuttles. Continuously manned since November 2000, the ISS has drawn its small rotating crew from 13 nations.

CHESLEY BONESTELL (ABOVE); NASA



BY GUY GUGLIOTTA

THE SPACE AGE BEGAN ON THE CHILL EVENING OF OCTOBER 4, 1957.

Sputnik, a 184-pound aluminum sphere tucked into the nose of a Soviet R-7 ballistic missile, streaked skyward from its launchpad near the edge of the Kyzyl Kum desert about a hundred miles east of the Aral Sea to become the first man-made object to orbit the Earth. An epoch of exploration and discovery as momentous as any in history had begun. Humans would go on to orbit the Earth, float in space, and—most spectacularly—set foot on the moon.

Just 15 years later it was over—after the last Apollo mission to the moon in December 1972. The space shuttle, a technological marvel at its debut in 1981, has proved to be fragile, expensive, and dangerous. And since it cannot fly beyond low Earth orbit, it has transformed spaceflight into a series of high-tech cruises to nowhere. When *Columbia* disintegrated over Texas during reentry in 2003, killing all seven of its astronauts, investigators decried the aimlessness of the human spaceflight program.

In response, President George W. Bush has outlined a new "Vision for Space Exploration": to return American astronauts to the moon by 2020 and eventually send them to Mars. The United States is ordering new rockets, building a new spaceship, making plans for a moon base—and, against long odds, trying to recapture the sense of urgency and adventure that propelled our first push into space.

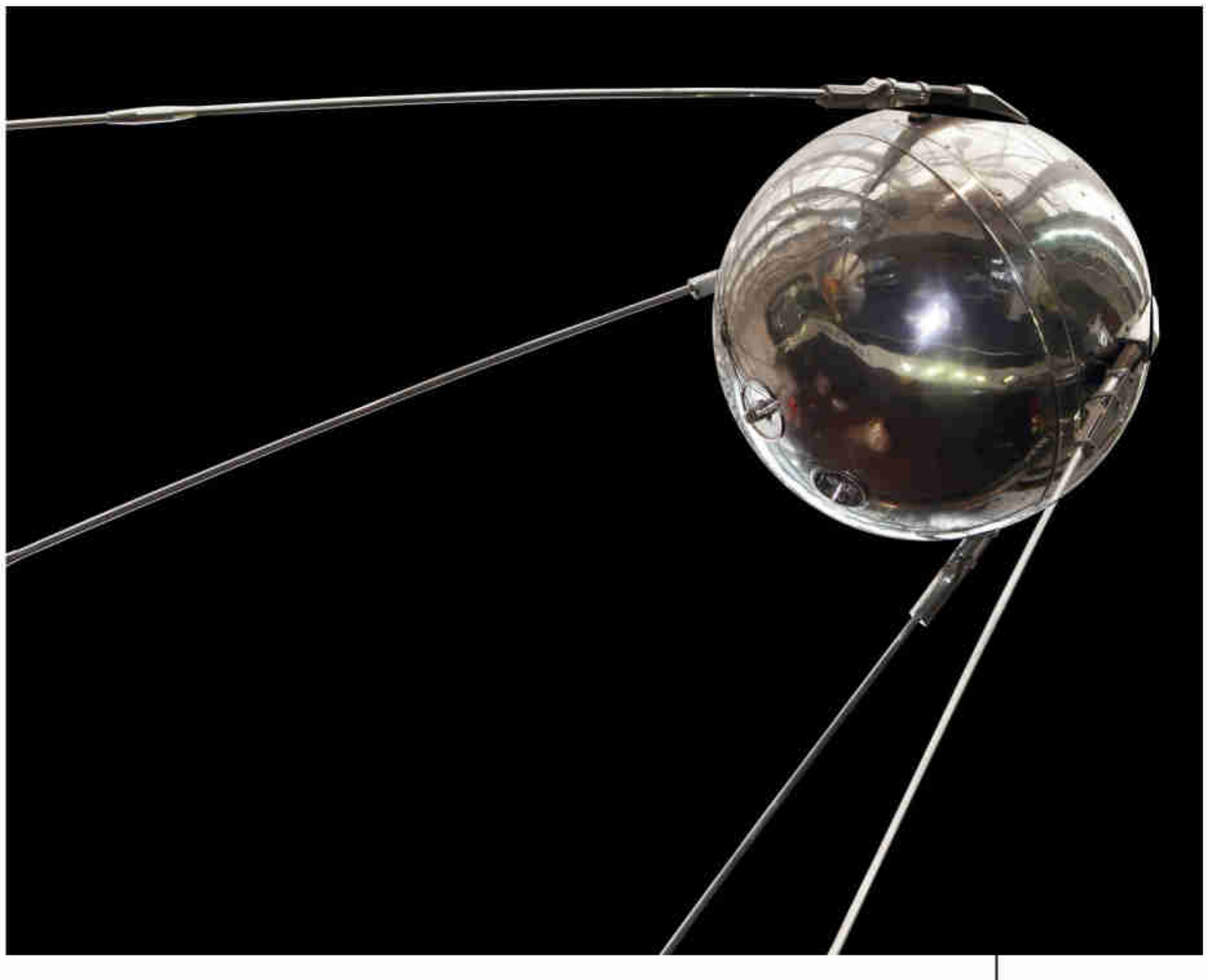
The R-7 rocket that launched Sputnik was a technological tour de force and a tremendous challenge to the West. Not only had Soviet scientists, led by legendary rocket designer Sergei Korolev, developed a rocket capable of flinging nuclear weapons to U.S. soil, they had opened the path to the moon and beyond. "The present generation will witness how the freed and conscious labor of the people of the new socialist society turns even the most daring of mankind's dreams into reality," declared a Soviet press release.

A month later the Soviets launched 1,120-pound Sputnik 2, six times heavier than its predecessor, with a dog named Laika aboard. Laika lasted only a few hours in the overheated spacecraft, but the Russians had made their point: If they could put a dog in orbit, they could send a human. Wernher von Braun, the transplanted Nazi scientist who would build the Saturn V rocket that launched the Apollo moon missions, begged Neil McElroy, the incoming secretary of defense: "For God's sake turn us loose."

Over the next few years, both the U.S. and the Soviet Union developed distinctive technologies, but they faced the same basic challenges. The physics of launch were, and are, immutable. An object flung into space has to reach a speed of between 17,000 and 18,000 miles an hour to attain low Earth orbit. To escape Earth's gravity altogether and fly somewhere else, a spacecraft must travel 25,000 miles an hour. The heavier the payload, the more powerful the rocket must be, and in this the Soviets initially had a huge advantage with the R-7. Four months after Sputnik, the U.S. did manage to orbit its first satellite, 31-pound Explorer 1—but by the end of the year the Soviets had launched Sputnik 3, weighing in at a ton and a half.

The ensuing rivalry produced a procession of spectacular achievements and heroes. In 1961 Soviet cosmonaut Yuri Gagarin, only 27, became the first human in space, circling the Earth once and parachuting home to a soft landing in a

Guy Gugliotta covered space and science for the Washington Post *for several years and is co-author with Jeff Leen of* Kings of Cocaine, *about the Medellín drug cartel.*



TRAILBLAZER In 1957, the Soviet Union launched Sputnik, a basketball-size capsule that became the Earth's first man-made satellite. Sputnik's radio signals were a "raspberry" from the Soviets, fumed one U.S. pundit. The next year, the United States created NASA, and the space race was under way.

plowed field. The next year, former Marine combat pilot John Glenn—later a U.S. senator—became the first American to orbit the Earth.

In 1963 came the first woman in space, Soviet textile worker Valentina Tereshkova. Cosmonaut Alexei Leonov took the first spacewalk in 1965, and in 1966 astronauts Neil Armstrong and Dave Scott performed the first space-docking maneuver.

Urged on by President John F. Kennedy's 1961 promise to put a man on the moon "before this decade is out," NASA's von Braun and the Soviet Union's Korolev sped through a regimen of increasingly complex test flights and orbital missions that culminated in the construction of two giant moon rockets, the American Saturn V and the Soviet N-1, each capable of lifting many tons into space.

Yet tragedy stalked both programs. On January 27, 1967, a fire triggered by an electrical short circuit broke out inside an Apollo space capsule during a training exercise at Kennedy Space Center, killing astronauts Gus Grissom, Ed White, and Roger Chaffee. The Apollo program stalled as Americans reeled from the space effort's first loss of human life.

The Soviet Union's program was already in trouble. Korolev died in 1966, and Soviet lunar efforts languished as the decade drew to a close. The Americans recovered, redesigning the flawed Apollo ship and launching the first manned flight aboard von Braun's giant Saturn V on December 21, 1968. The Soviets, hoping to stay in the race, launched the N-1 on its second test flight on the evening of July 3, 1969. Several hundred feet above the launchpad a metal part

MARK THIESSEN, NG PHOTOGRAPHER; MODEL COURTESY NASA/NATIONAL SPACE SCIENCE DATA CENTER (NSSDC)

shook loose, and seconds later the fully fueled, six-million-pound behemoth fell to Earth, exploding in a giant fireball that destroyed the launch complex and Soviet lunar ambitions. Seventeen days later, on July 20, 1969, the Saturn V delivered Michael Collins, Neil Armstrong, and Buzz Aldrin to the moon. Excitement in the U.S. reached apogee.

Three years later the golden age was over. The U.S., strapped for cash during the Vietnam War, abandoned the moon to build the space shuttle and, more recently, the International Space Station. The Soviets, plagued by money problems and rivalry, turned away from the moon and focused on long-duration spaceflight in orbiting laboratories, first Salyut, then Mir.

Public interest in human spaceflight waned. The political imperative faded with détente and later with the fall of the Soviet Union. But it was probably the relative decline in technological bravura that did the most to kill off the audience. Space travel, perhaps the most visionary of all human endeavors, today derives most of its romance from exploits that ended 35 years ago.

In low Earth orbit, the main attraction of human spaceflight was spacewalks, whose novelty soon wore off. Some of the recent ones, requiring astronauts to juggle tons of Erector set components in constructing the space station, are as difficult as any ever attempted, but the nuances of this arcane skill are lost in the viewing. The painstaking movements that unfold so slowly in the weightlessness of space sap the tension from these events. Spacewalking, 42 years after it was invented, is about as spectator-friendly as croquet.

The torch of novelty passed to the robots. The unmanned missions proved their worth early with probes like the Soviets' Venera, which in 1975 descended through clouds of sulfuric acid toward the surface of Venus, withstanding temperatures of 900°F and pressures equivalent to 90 Earth atmospheres in order to transmit the first images of the surface of another planet. NASA's Voyager 1, launched in 1977 and still transmitting today from the frontier of interstellar space, sped past Saturn and turned backward on February 14, 1990, for a final snapshot: a first ever family portrait of the solar system from the outside looking in. "After that we shut the cameras off," recalls Voyager project manager Ed Massey. "There was nothing left to shoot."

Recent years have brought, among many other triumphs, the rovers Spirit and Opportunity, driving on the surface of Mars since 2004; Cassini, currently touring Saturn and its moons; and Deep Impact, which dropped an 820-pound projectile into the path of a comet in 2005, then analyzed the resulting crater and debris plume to determine its composition. Orbiting observatories, beginning with the Hubble Space Telescope, provide a never ending supply of breathtaking images of the cosmos.

DESPITE ITS SHIFTING FORTUNES, manned space exploration still retains a viselike grip on the human imagination. Indeed, although it is impossible for all but VIPs, reporters, and NASA employees to get really close to a space shuttle launch at the Kennedy Space Center, crowds still gather on the banks of the Indian River 11 miles away to witness a heart-stopping event that never disappoints—more than seven million pounds of thrust in a controlled explosion hurling a 4.5-million-pound object into the heavens at 25 times the speed of sound.

But it will take the next few years to tell whether humanity's enduring fascination with space will produce another magnificent adventure like the one that began half a century ago. The new moon-Mars effort has brought a fresh air of bustle, but also a real danger that the whole project could fizzle away in a few years with little to show but dusty blueprints. Without a Cold War space race to stoke the competitive fires, the urgency has waned and the money—all but unlimited during the golden age—is scarce and coming slowly this time around.

According to some reports, the first part—reaching the moon and building a permanent base there—can be done for a relatively modest 217 billion dollars spread over 20 years. Describing the moon-Mars initiative as "a journey, not a race," President Bush has said it can be funded



RISING AMBITIONS Rolling toward the launchpad a few days before liftoff in October 2005, the Shenzhou 6 carried two "taikonauts" into orbit. It was the second manned spaceflight for China, which is only the third nation—after Russia and the United States—to have sent humans into orbit.

piecemeal without big hikes in NASA's annual budget—unlike the crash program that followed Kennedy's moon promise. During that race (most definitely not a journey) NASA at times commanded nearly 4 percent of the annual U.S. budget. NASA's 17.3-billion-dollar request for 2008 is about 0.6 percent of the total.

Living on the moon will also require technological leaps never contemplated during the Apollo missions. Astronauts must survive prolonged exposure to lethal radiation and build a lunar encampment—perhaps from empty lunar module fuel tanks—that can withstand temperatures ranging from 240°F above zero to 240°F below. They must have space suits that can cope with the abrasive effects of moondust—the microscopic potpourri of jagged glass and rock that nearly froze the joints of Apollo space suits after only three days of moonwalks. The new lunar explorers will have to learn to extract oxygen from the dust to use for rocket fuel, breathable air, and water for drinking and radiation shielding. Mars is a project for the next generation—or the one after that.

NASA calls the new space mission Constellation, and has already ordered construction of new spacecraft—a 1960s-like capsule called Orion, famously described by NASA Administrator Michael D. Griffin in 2005 as "Apollo on steroids." Boosted by a souped-up version of a solid-fuel shuttle rocket called Ares I, Orion will carry a crew of six to the space station and later a group of four to the moon. NASA is also planning a much larger cargo rocket called Ares V, which will be able to lift as much as 150 tons to orbit, including the booster rocket, lander, and other hardware needed for a moon expedition.

The first few Constellation moon trips—to begin perhaps as early as 2018—will be sorties to reconnoiter a projected outpost at the lunar south pole. Longer missions will follow. Astronauts will use the base both to explore the moon

CHINA PHOTOS/GETTY IMAGES

Human Spaceflights

Since 1961, 460 men and women from nearly 40 countries have been on 267 trips into space. Only two dozen people have soared beyond low Earth orbit, and none since the last moon landing in 1972. While another moon shot is at best a decade away, space entrepreneurs aspire to put tourists in orbit.

1,000,000 km

Moon

MOON RACE

Apollo 11 astronauts Neil Armstrong and Buzz Aldrin made the first lunar landing July 20, 1969. Having lost the race, the Soviets never attempted to match the feat.

100,000 km

Geostationary communication satellites orbit at 36,000 km.

10,000 km

GPS satellites orbit at 20,200 km.

1,000 km

100 km

First manned lunar orbit

FIRST LUNAR LANDING: APOLLO 11

Exposed to vacuum of space

First man in space: Yuri Gagarin

First American to orbit the Earth: John Glenn

First woman in space: Valentina Tereshkova

First spacewalk: Alexei Leonov

Apollo 1 three-man crew killed by fire during a test
Vladimir Komarov dies during reentry of Soyuz 1

Soyuz 11 three-man crew killed when exposed to vacuum of space

First U.S. space station: Skylab

First 100-plus-day flight, on Salyut 6

First space shuttle flight: *Columbia*

Challenger explodes during liftoff, killing all 7 crew members

1961 1965 1970 1975 1980 1985 1990

THE MISSIONS

United States

MERCURY 1961-63	GEMINI 1965-66	APOLLO 1968-75	SKYLAB Space Station 1973-74 (deorbited 1979)	SPACE SHUTTLE 1981-present

X-15 1963

U.S.S.R.

VOSTOK 1961-63	VOSKHOD 1964-65	SOYUZ 1967-present	SALYUT Space Station 1971-86 (deorbited 1991)	MIR Space Station 1986-2000 (deorbited 2001)

LOW EARTH ORBIT

Nearly all human space travel has taken place within low Earth orbit, the region that lies between 200 and 2,000 kilometers (125 to 1,240 miles) above the planet's surface.

A NEW SPACE RACE



MOON

The U.S. aims to return astronauts to the moon by 2020 and ultimately build a permanent lunar base. China has also announced lunar ambitions.

MARS

The moon would be the launchpad for exploration to Mars and beyond, in the U.S. moon-Mars initiative. A manned mission to Mars is not expected for two or more decades.

Longest spaceflight: Valery Polyakov, 437 days

LOW EARTH ORBIT ▼
2,000 km

KÁRMÁN LINE
The boundary between Earth's atmosphere and space lies roughly 100 km above sea level.

First tourist in space, Dennis Tito, pays $20 million for his trip

Space shuttle *Columbia* disintegrates during reentry into atmosphere, killing all 7 crew members

First Chinese manned flight

First privately funded manned spaceflight: *SpaceShipOne*

The International Space Station orbits between 320 and 380 km.

1995 2000 2005 2007

China
SHENZHOU
2003-present

International Space Station 1998-present

Private enterprises
SPACESHIPONE
2004

Russia

KEY
Fatalities

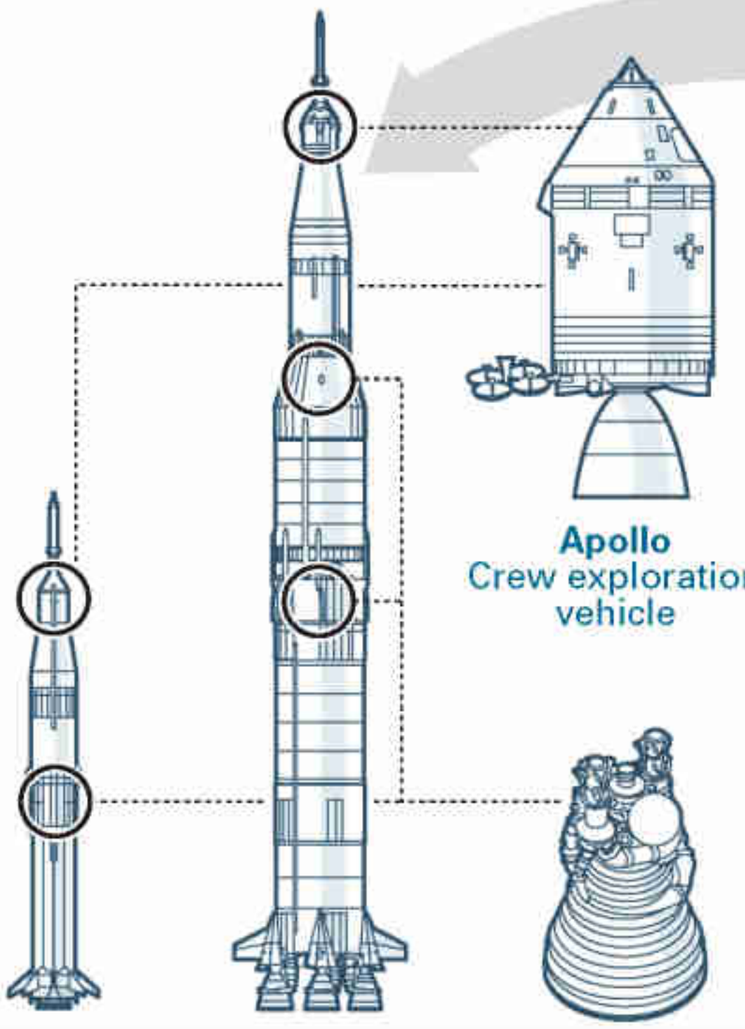
Spacecraft not to scale

SOURCE: ROBERT BRAEUNIG, *ROCKET AND SPACE TECHNOLOGY*

REPORTED BY KRIS GOODFELLOW; ART AND DESIGN BY JUAN VELASCO, NGM ART; SPACECRAFT ART BY JONATHAN AVERY, NGM ART

Rocket Science

In the evolution of spacecraft, trends are markedly retro. The U.S., Russia, and China all are going back to the future by developing new vehicles inspired by older ones. "When mission success is everything," says aerospace engineer David Akin, "nobody wants to be the first to try something new. And it's a lot cheaper to copy something that you know works."



U.S.A.

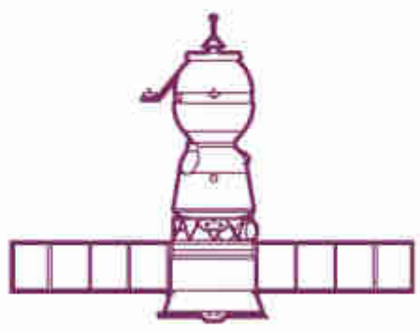
NONREUSABLE IN-LINE ROCKETS

Saturn-Apollo *1968-1975*

Designed to take astronauts to the moon, the Apollo spacecraft could carry a crew of three. The Saturn V rocket launched lunar missions; Saturn IB carried two Apollo manned missions into Earth orbit.

Soyuz
1967-present

Used in more missions than any other craft, the Soyuz series keeps evolving. Today's model holds three cosmonauts; its "wings" are solar panels.



U.S.S.R.



N-1
1969-1972

Similar to Saturn, it was designed to beat the U.S. to the moon, but all four unmanned test launches failed.

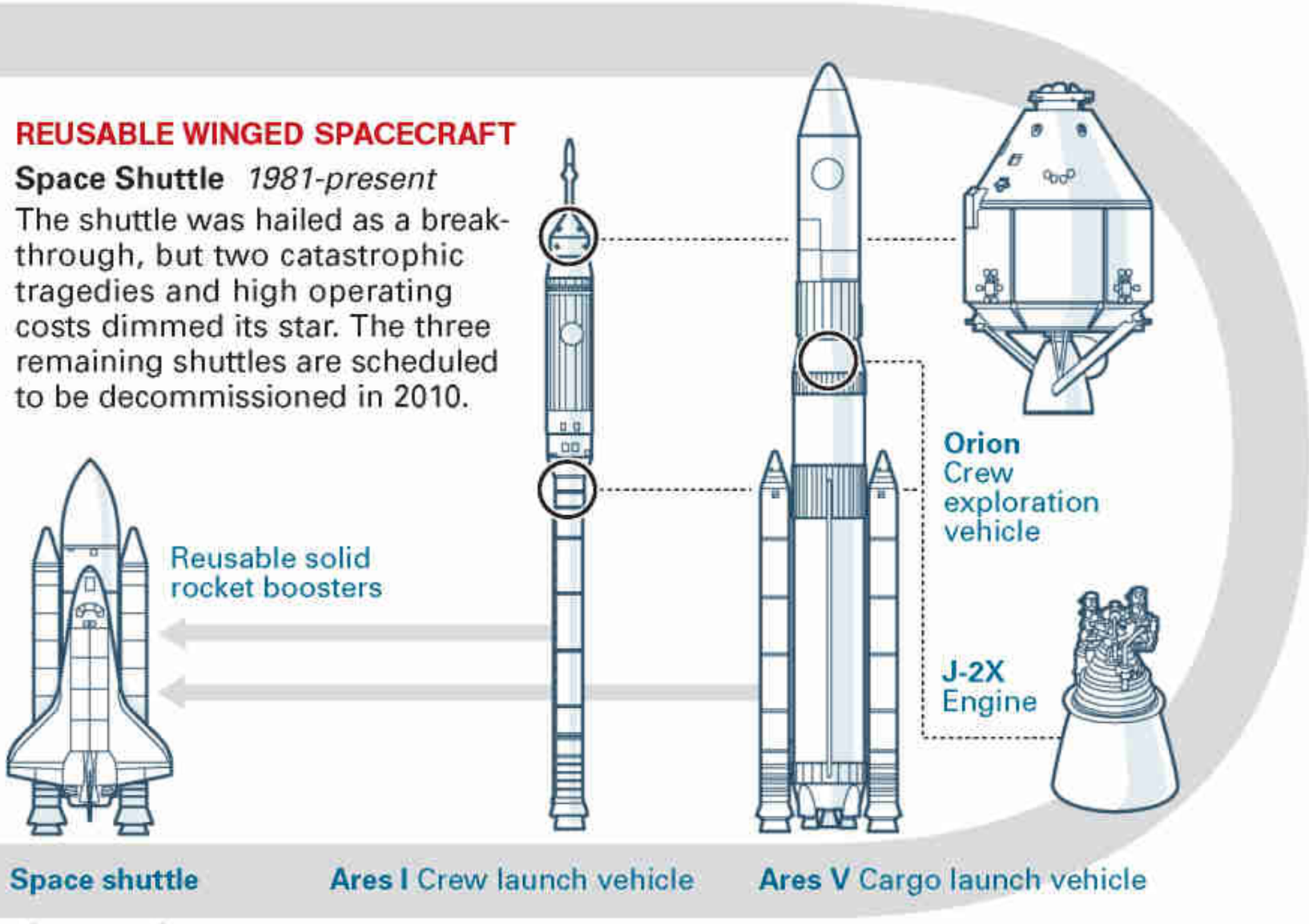
Drawings not to scale

and to develop and test survival strategies and technology for the more ambitious Mars missions.

Mike Griffin, a plainspoken rocket scientist with previous experience at NASA, the Defense Department, and in private aerospace industry, is masterminding the moon-Mars effort. He has drastically reordered NASA's priorities to give the initiative a shot at succeeding. Although he praises the shuttle as a "stunning advance in capability and technology," he never liked the program. The remaining orbiters—*Discovery*, *Atlantis*, and *Endeavour*—will be retired by the end of 2010, as soon as they finish ferrying components to the space station, nearly two-thirds complete. The shuttle's departure will not be mourned. "It was something well before its time, filled with the hubris of Apollo," says space historian John Logsdon. "In the end, the shuttle era will be regarded as an interlude in the development of space exploration capabilities."

When the shuttle age is over, Griffin would like NASA to abandon low Earth orbit projects so it can focus on the moon. Although Orion will be able to carry supplies and astronauts to and from the space station, Griffin prefers to have private enterprise build a workaday rocket for that job, and has ponied up 500 million dollars to help Space Exploration Technologies, a California company owned by PayPal founder Elon Musk, and Rocketplane-Kistler, of Oklahoma City, develop and deliver the new vehicle.

The possibility that private industry might one day provide off-the-shelf rocketry and spacecraft to whoever wants to buy them was unthinkable during the Cold War space race, when virtually every new step was an ultra-expensive



technological leap into the unknown. But "new space" is emerging as a serious industry, marrying the know-how of innovative engineers to the cash and acumen of self-made multimillionaires. Musk, not yet 40, dropped out of graduate school in 1995 to earn the first of two Internet fortunes. Burt Rutan, the flamboyant aerospace engineer with muttonchop sideburns, designed and built *SpaceShipOne,* then had his astronauts fly it twice in two weeks into suborbital space to win ten million dollars offered by the nonprofit X Prize Foundation to encourage the development of low-cost spaceflight. Rutan's partner in that venture was Microsoft co-founder Paul Allen. Now Rutan is teamed with Virgin Galactic's Sir Richard Branson to develop *SpaceShipTwo,* as a tourist vehicle that would carry six passengers on quick up-and-downs at a starting price of $200,000 a seat.

Besides rockets, new space will also need launchpads and destinations. Earlier this year the state of New Mexico introduced a new sales tax to fund the 200-million-dollar Spaceport America, to be built in the desert near Truth or Consequences. And outside Las Vegas, hotel magnate Robert Bigelow is designing and building inflatable space stations. On the ground they look like large umbrellas waiting to unfold, with soft, but durable, fabric wrapped around a rigid core. In space, the fabric would balloon to form compartments. Instruments, life-support machinery, and supplies are stored in the core. A small, unmanned version dubbed Genesis I opened like a flower 346 miles above the Earth in July 2006 and has operated flawlessly ever



TAKING THE HEAT

During a test at New Mexico's Sandia National Labs, some 5,000 mirrors concentrate sunlight into an intense beam that vaporizes the surface of an ablative heat-shield panel. Such heat shields on the outer skin of a spacecraft are designed to lose mass as the vehicle reenters Earth's atmosphere, protecting occupants from frictional heat that can create an environment hotter than the sun's surface.

MARK THIESSEN, NG PHOTOGRAPHER



since. Bigelow successfully launched a second prototype in June of this year and intends to put a three-person module in orbit in 2010 and offer space-training programs for astronauts by 2012. Ultimately he hopes to lease modules for use as hotels, labs, or movie studios. Bigelow, who says he got into real estate to earn enough money to indulge his lifelong fascination with space, is a frequent spokesman for new space and is militantly opposed to publicly funded space travel: "It's not right for governments to be in direct competition with taxpaying companies," he says. "It's almost heresy in capitalism."

In Russia, however, the state is the one looking to make the space profits. In 2001 the Russian space agency Roskosmos began a tourism program by putting American multimillionaire Dennis Tito in a Soyuz capsule and sending him on a visit to the space station. Software developer Charles Simonyi became the fifth space tourist earlier this year, paying more than 20 million dollars for the trip.

GRIFFIN HAS A ZEALOT'S BELIEF in human exploration of the solar system and has managed to convey this enthusiasm to a once skeptical Congress, giving the new initiative a powerful bipartisan constituency that may enable it to survive the next presidential election. Just as important, he convinced lawmakers to let the shuttle go, and without the shuttle, Orion must move forward, or the U.S. will no longer have a cutting-edge spaceship of its own—a politically unpalatable alternative for many, especially with China inching forward.

Few westerners have visited China's Jiuquan Launch Center in the Gobi desert. But photographs show facilities strikingly similar to those of NASA's Kennedy Space Center. Vehicles like those that transport the shuttle carry Chinese rockets to launch after the finishing touches have been added in a smaller version of NASA's main assembly building. On October 15, 2003, Chinese astronaut Yang Liwei was boosted into orbit from Jiuquan, making China the third nation to put humans into orbit.

Does China's arrival in orbit herald the start of another space race? "The Chinese and the Americans are a bit like the tortoise and the hare," says Joan Johnson-Freese, a Chinese space expert with the Naval War College. "The Chinese plod along, launching every few years. The Americans sprint, but haven't been consistent." China is methodically acquiring the same skills the Soviets and Americans built during their space race. Two Chinese astronauts made a second flight in October 2005. A third flight in 2008 is expected to carry three crewmen. Tang Xianming, a director of China's Piloted Space Program Office, says his country wants a space station of its own and is eyeing the moon.

Griffin is not at all unwilling to play up the possibility of a rivalry. Competition fueled the golden age of space, and could end up doing so again. "Will my language be passed down over the generations to future lunar colonies?" he asked in a 2006 speech to the International Astronautical Congress. "Or will another bolder or more persistent culture surpass our efforts and put their own stamp on the predominant lunar society of the far future?"

Others question whether the prize would be worth the cost. They say the return to human space exploration shortchanges the future of unmanned missions just to pay for a quixotic and expensive Apollo rehash. Besides the revelations and sheer wonder delivered by space probes, telescopes, and other instruments, unmanned missions have also produced transformational benefits to humanity in Earth observation, weather forecasting, navigation, and telecommunications. And robots don't need space suits, radiation shields, toilets, exercise bikes, a bailout system during launch, or any consumables to speak of except energy.

There's no argument when it comes to costs: Cassini, NASA's glittery high-end robotic mission to Saturn, cost the U.S. 3.4 billion dollars, but has been studying the ringed planet and its moons since 2004 and will likely produce pathbreaking science for at least another decade. Deep Impact cost 333 million dollars, and the spacecraft that delivered the projectile is headed for a new mission, probably a rendezvous with a comet. By contrast, shuttle flights, which last around two weeks, cost about a billion dollars apiece in 2002, the

Exploring Space Without Humans

LOOKING BACK From seven million miles away, Voyager I transmitted this first ever image of the Earth and moon in 1977, then sped off on a 30-year journey to deep space that's still under way. Such unmanned space probes have gathered galaxies of data at a fraction of the cost of the human space program.

NASA/JPL–CALIFORNIA INSTITUTE OF TECHNOLOGY





ZOOMING IN ON MARS

When Mariner 4 passed by Mars in 1965, it captured the first close-up of the planet (left). In 1997, the Mars Global Surveyor arrived and orbited for nearly ten years. Its high-resolution camera snapped more than 240,000 pictures, including shots of Mars as a global dust storm clouded its atmosphere (below).

NASA/NSSDC (TOP); NASA/JPL/MALIN SPACE SCIENCE SYSTEMS (MIDDLE, BOTTOM)

CRUISING BY JUPITER

Swirling belts of clouds—made of ammonia, hydrogen sulfide, and water—blanket Jupiter in this mosaic created with 27 images taken by the spacecraft Cassini. Launched in 1997, Cassini flew past Venus, Earth, and Jupiter to build up speed as it slingshotted off to its ultimate destination—Saturn.

NASA/JPL/SPACE SCIENCE INSTITUTE

last year before the *Columbia* tragedy, and costs have soared since then.

Griffin's decision to redirect NASA's budget toward human space travel has already curtailed planned funding growth for space science and Earth science. NASA's science budget is projected to remain virtually the same—about 5.5 billion dollars a year—through 2011, while funding for the moon-Mars initiative more than doubles to 8.7 billion dollars. A mission to look for water ice on Jupiter's moons and two missions to detect Earthlike planets around other stars have been canceled or put on indefinite hold, while budgets for in-house research and analysis, individual research projects, and future low-budget space missions have all been cut.

In January, the Pasadena, California-based Planetary Society, an influential advocacy group, gathered 5,000 signatures for a petition to President Bush protesting these cuts and urging him to "salvage" the "proud history of innovation and exploration in space—before it's too late."

Why bother with human spaceflight, when robots do such a good job and do it so much more cheaply? Proponents of human spaceflight argue that only humans have the supple physical coordination and mental agility to get the most from an expedition. But the most compelling argument for human spaceflight may remain the one that worked at the beginning. Space exploration is ultimately about human dreams.

The United States owned the Louisiana Purchase as soon as Thomas Jefferson bought it from the French, but the first thing he did was send Lewis and Clark to walk the property. It isn't really yours until you've been there, say advocates of human space exploration. "I do not see any need at all to justify human spaceflight on the grounds of what it's going to do for science. It will do a lot for science, but that's an 'oh, by the way,'" Griffin says. "The drive to extend our reach—human destiny—is reason enough to go." □

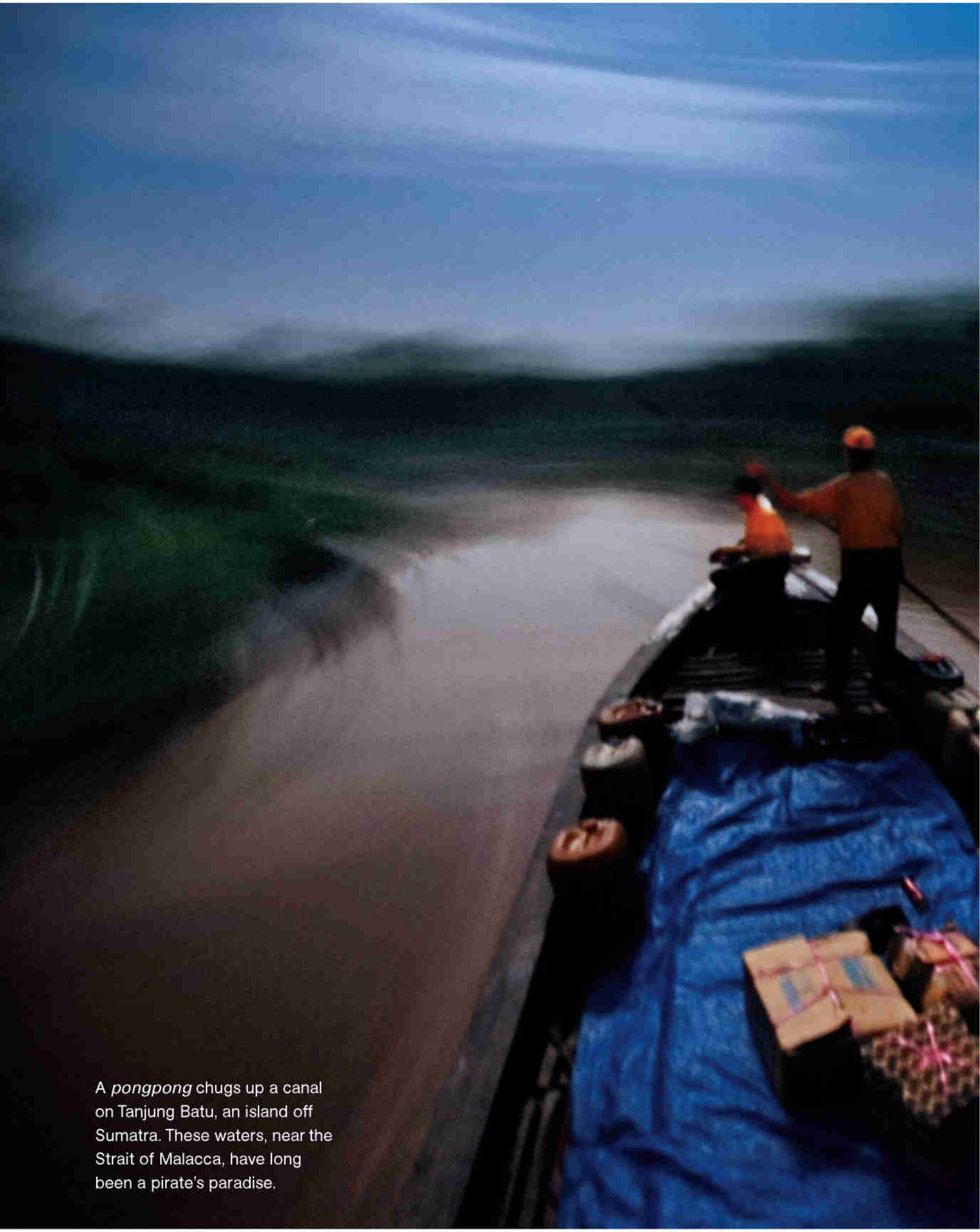
Looking Back, Looking Forward From Sputnik to Saturn's moons, see 50 highlights from 50 years of space exploration at **ngm.com/0710**.



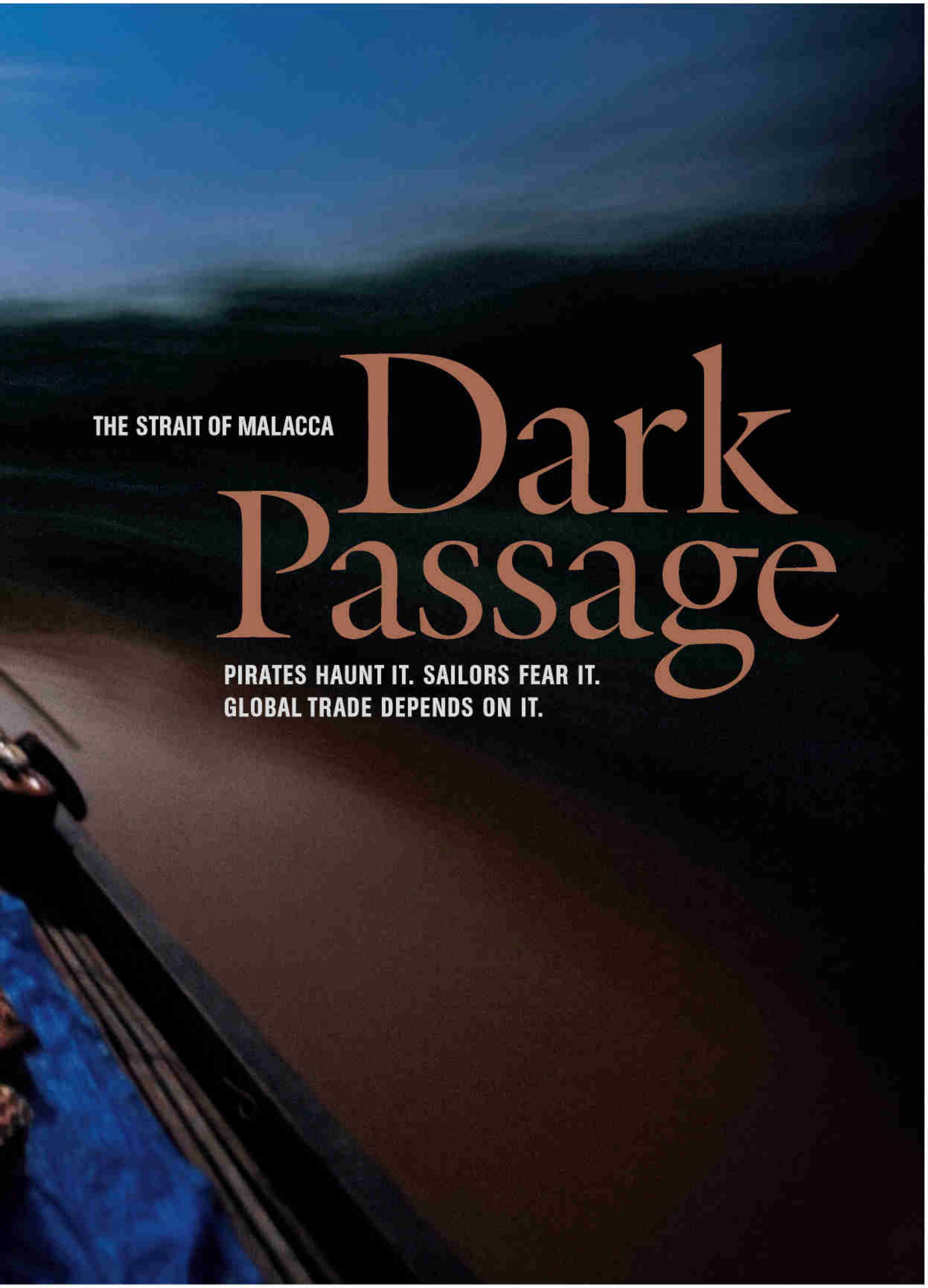
MARK THIESSEN (NG PHOTOGRAPHER) AND SCOTT ANDREWS



NEARING THE END *Discovery* embarked last December on its 33rd mission; the three shuttles are slated to be decommissioned by the end of 2010. Next up from NASA: a new generation of rockets and vehicles—dubbed Ares and Orion—designed to carry astronauts back to the moon, and from there, perhaps, to Mars.



A *pongpong* chugs up a canal on Tanjung Batu, an island off Sumatra. These waters, near the Strait of Malacca, have long been a pirate's paradise.


THE STRAIT OF MALACCA
Dark Passage
PIRATES HAUNT IT. SAILORS FEAR IT.
GLOBAL TRADE DEPENDS ON IT.



Armadas of container ships ply the Malacca Strait, many stopping at Singapore. The channel, a global choke point, transits one-fifth of all seaborne trade and a third of the world's crude oil shipments.



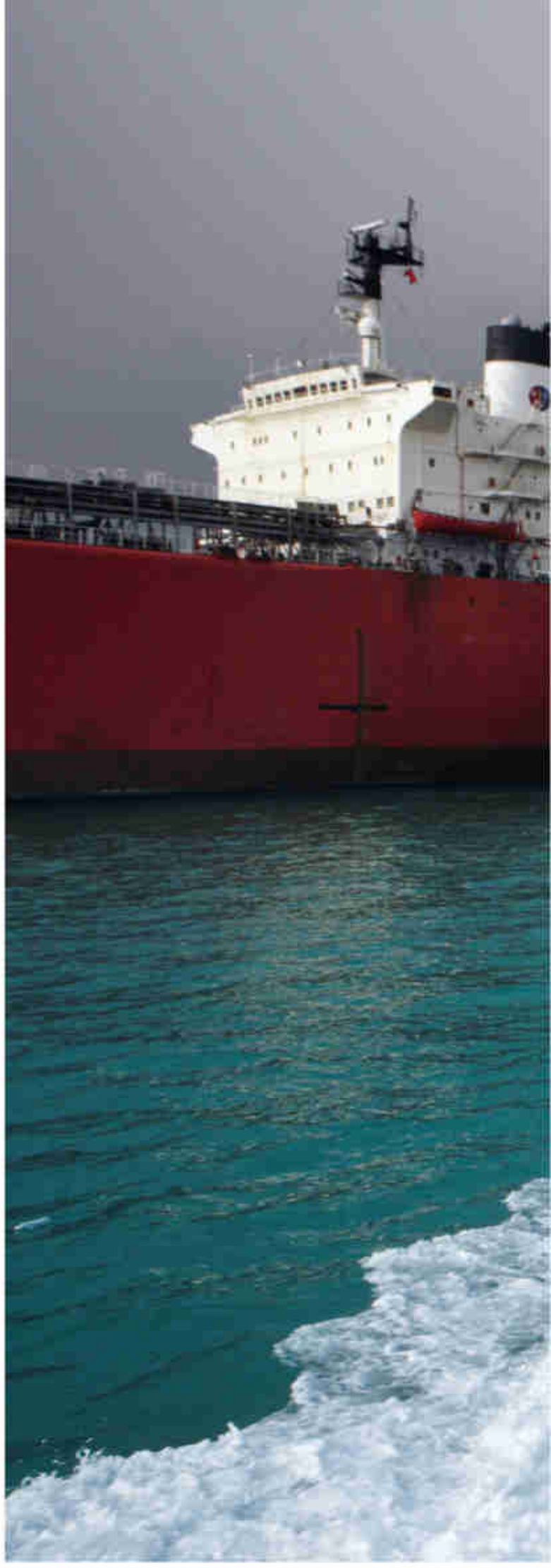




Pool halls on Indonesia's Batam Island serve as a nexus for maritime gossip and dealmaking. Pirates sometimes recruit among the commercial sailors, many unemployed, who gather there.

BY PETER GWIN NATIONAL GEOGRAPHIC STAFF

PHOTOGRAPHS BY JOHN STANMEYER



"I CAN SMELL THE SEA FROM HERE," says the prisoner. That seems a wild improbability coming from a man in a soundproof cell in northern Malaysia, several miles as the gull flies from the closest salt water. All I can smell in this humid, whitewashed prison is the faint tang of ammonia used to clean the floors.

It is hard to know what to believe of the prisoner's claims. At times he has declared his innocence and then later confessed to being a willing criminal. He mentions he has three children, later the number is four. His passport lists his name as Johan Ariffin, but Malaysian authorities doubt that's his real name. His age is noted as 44 (streaks of gray in his black hair make that plausible) and his residence as Batam, an Indonesian island just south of Singapore. Men like him often come from Batam, a guard says.

Though his jailers remain unsure who he is, they know exactly what he is: *lanun* (pronounced la-noon). When asked for a direct English equivalent, an interpreter explains that there is none, that it is a word freighted with many layers of culture and history. The short, imperfect answer is: The prisoner is a pirate.

He earned that epithet when Malaysia's marine police captured him and nine accomplices after they hijacked the *Nepline Delima*, a tanker carrying 7,000 tons of diesel fuel worth three million dollars, in the Strait of Malacca. It was one of several attacks reported during 2005 in the 550-mile channel separating the Indonesian island of Sumatra from the Malay Peninsula, Singapore perched at its southern tip.

For centuries, this sliver of ocean has captivated seamen, offering the most direct route between India and China, along with a bounty of resources, including spices, rubber, mahogany, and tin. But it is a watery kingdom unto itself, harboring hundreds of rivers that feed into the channel, miles of swampy shoreline, and a vast constellation of tiny islands, reefs, and shoals. Its early inhabitants learned to lead amphibian lives, building their villages over water and devising specialized boats for fishing, trading, and warfare. Some made their living as pirates, preying on foreign vessels that dared to ply their waters. Armadas of these skilled sea raiders in light, maneuverable craft regularly plundered passing ships and retreated upriver to fortified villages. Their raids yielded troves of gold, gems, gunpowder, opium, and slaves, which they used to build powerful sultanates that dominated much of the Sumatran and Malaysian coastlines.

Sailors chronicled the horrors they faced in the strait and nearby waters. One 19th-century episode involved the capture of British Captain James Ross. Believing his ship held a stash of silver coins, lanun forced him to watch as his young son was lashed to an anchor and drowned.



PIRATE PATROL A Malaysian police officer scans an anchorage outside the port of Tanjung Pelepas. Patrols by Indonesia, Malaysia, and Singapore, peace in Sumatra's restive Aceh Province, and an uptick in the region's economy have helped curb pirate attacks.

Then they cut off Ross's fingers joint by joint.

European colonizers and their navies brought the sultanates under control in the late 1800s, but the lanun were never eradicated. The 21st-century inheritors of their tradition continue to hunt these waters, mainly in three incarnations: gangs that board vessels to rob the crews; multinational syndicates that steal entire ships; and guerrilla groups that kidnap seamen for ransom.

Modern lanun have no shortage of targets. Each year, according to Lloyd's of London, some 70,000 merchant vessels carrying a fifth of all seaborne trade and a third of the world's crude oil shipments transit this critical choke point in the global economy. The strait's geography makes it nearly unsecurable. It passes between Malaysia and Indonesia, known for thorny relations, further complicating the security picture. Some 250 miles wide at its northern mouth, the strait funnels down to about ten miles across near its southern end and is dotted with hundreds of uninhabited mangrove islands, offering endless hideouts to all manner of criminals.

Since 2002, the International Maritime Bureau (IMB) has recorded 258 pirate attacks in the Malacca Strait and surrounding waters, including

Photographer John Stanmeyer lives in Indonesia. He has documented social issues in more than 30 countries and is working on a project about AIDS in Asia.

more than 200 sailors held hostage and 8 killed. The insurance arm of Lloyd's classified the strait as a war zone in June 2005. Malaysia, Singapore, and Indonesia responded by bolstering security in their respective waters, and Lloyd's suspended the rating in August 2006.

But counting pirate attacks is murky business. Noel Choong, head of the IMB's Piracy Reporting Centre, estimates that half of all pirate attacks go unreported. "In some cases the ship's owners dissuade the captain from reporting an attack," he says. "They don't want bad publicity or the ship to be delayed by an investigation." As a result, no one knows for sure how many pirates remain active in the Malacca Strait.

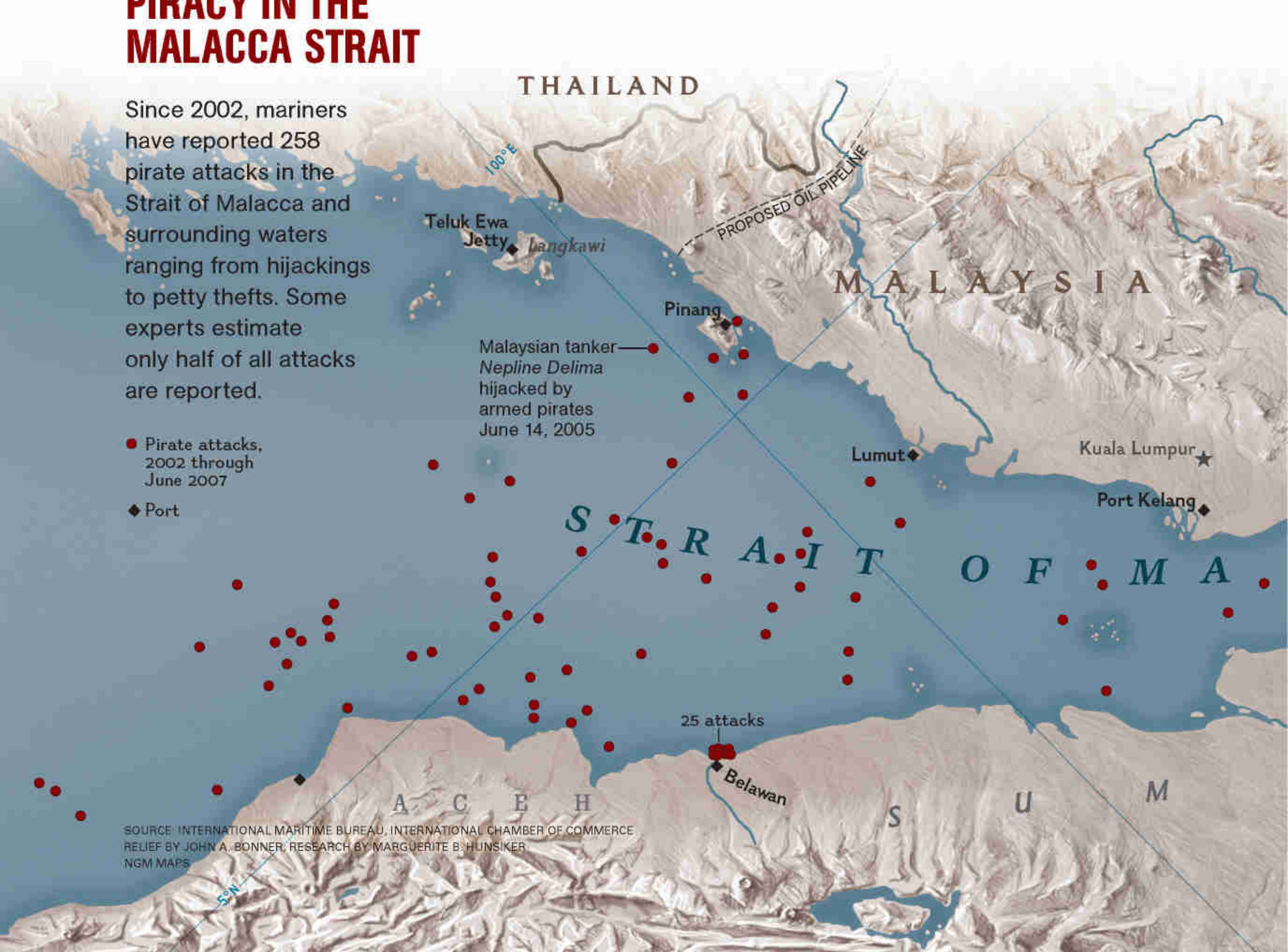
OCEAN PREDATOR Which brings us back to Ariffin, who is serving a seven-year prison sentence. A lawyer hired by the Indonesian consulate has been his only visitor. The closest the guards let me get to him is the other side of a scratched, bulletproof window looking onto an interview cell. When the guards bring him in, he isn't the imposing figure I'd envisioned. He stands barely five feet tall, and his open collar reveals a faded heart tattooed on his sagging chest. He looks more like a weary pickpocket than a pirate, confused that a foreigner has requested to see him.

He and my interpreter pick up telephones on either side of the window. I explain that I have read about his case. That I have traveled from the other side of the world to hear his story; to ask him why he became a lanun; to hear how it is possible for a handful of men to hijack a ship as large as the *Nepline Delima.*

Ariffin sits silently, the telephone pressed to his ear, his eyes shifting between the interpreter

PIRACY IN THE MALACCA STRAIT

Since 2002, mariners have reported 258 pirate attacks in the Strait of Malacca and surrounding waters ranging from hijackings to petty thefts. Some experts estimate only half of all attacks are reported.



SOURCE: INTERNATIONAL MARITIME BUREAU, INTERNATIONAL CHAMBER OF COMMERCE
RELIEF BY JOHN A. BONNER; RESEARCH BY MARGUERITE B. HUNSIKER
NGM MAPS

and me, his shirt damp with sweat. "The lawyer took all my money," he says finally. "I have no soap. I haven't brushed my teeth since I got here."

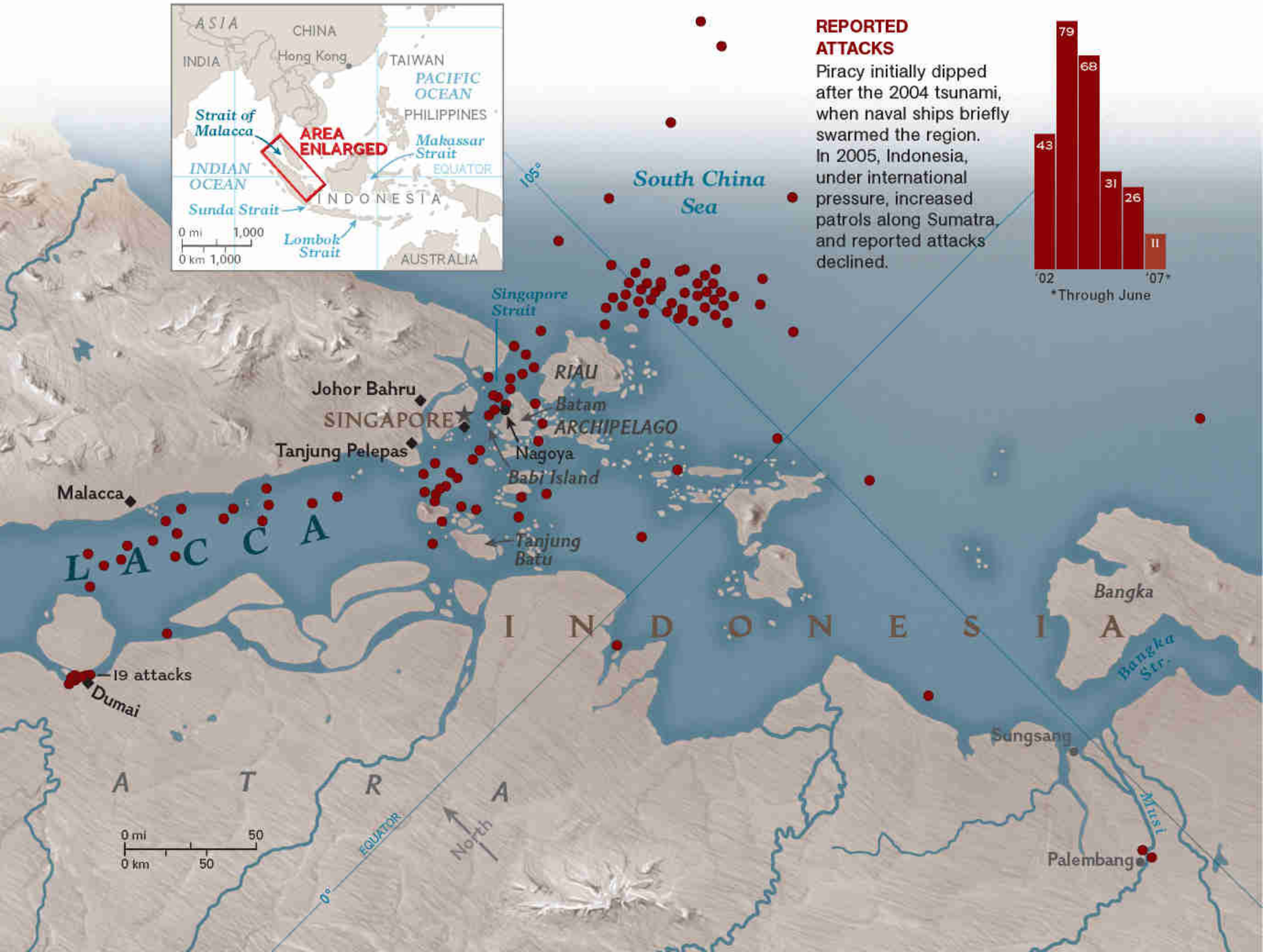
I offer to leave some toiletries for him with the guards. His demeanor brightens, and slowly he begins his story, or at least one version of it.

The plot was hatched in a Batam coffee shop, Ariffin says, when a Malaysian shipping executive approached an Indonesian sailor named Lukman and inquired whether he could organize a crew to hijack the tanker. Ariffin, who went to sea in his teens and rose through the maritime ranks to become a mechanic, had served with Lukman on a few crews. Lately both of them had struggled to find work, and Lukman asked if he wanted in on the heist. It would be an easy job, he promised, because a member of the tanker's crew was in on the plan.

As a young crewman, Ariffin says he was once on a ship attacked by pirates. They waved parangs (machete-like knives), threatened to kill everyone, and took cash and food. He smiles wryly at the irony. "It is very hard for Indonesian seamen. We all need money."

He told Lukman he was in. "All we had to do was board the tanker, tie up the crew, and sail to open sea," Ariffin says. They would meet a tanker coming from Thailand, transfer the fuel, and abandon the *Nepline Delima.* Lukman promised Ariffin $10,000 for manning the tanker's engines.

The plan began smoothly. Posing as tourists, Ariffin, Lukman, and two other seamen from Batam pretended to snap photos as they rode a ferry up the strait to the Malaysian port of Pinang. There they met six other men Lukman had recruited from Aceh, Sumatra's northernmost province. "They weren't seamen," said Ariffin. "We needed their muscles."





RED LIGHT ISLAND A secluded establishment on Babi Island—once a favorite pirate haunt—offers cold beer, loud karaoke, and private rooms in the back. Impoverished women are recruited from across Indonesia to work in similar places throughout the Riau Archipelago.

At a nearby beach, they stole a fiberglass speedboat, painted it blue, and loaded it with gasoline, water and food, two cell phones, a GPS, and five freshly sharpened parangs. In addition, each man brought a ski mask, a change of clothes, some cash, and a passport. After midnight, they slipped into the strait. Meanwhile, the turncoat crew member was sending text messages from the tanker, updating the ship's position, course, and speed. Most important, Ariffin said, "he told us when he would man the watch."

A few hours later, the pirates, wearing ski masks and wielding parangs, commanded the *Nepline Delima*'s bridge. The tanker's distress signal had been disabled, and 16 of its 17 crew lay bound and blindfolded in a locked cabin, some of them bleeding. The pirates set a new course for the Thai tanker on the open sea. By the next evening the gang would be on their way back to what Batam pirates call "happy happy," a blur of hedonism, ranging from extravagant amounts of crystal meth and ecstasy to marathon sessions with prostitutes. Or, if Ariffin is to be believed, home to his family.

The problem was the 17th crewman. Soon after the pirates had boarded the tanker, Ariffin, guarding the speedboat, heard one of the sailors yell: "Lanun!" Bedlam erupted on the ship's decks as the pirates tried to round up the frightened crew. Lukman and two others were on the



bridge. They switched on the public address system and started beating the captain until his shouts for the crew to surrender blared over the ship's loudspeakers. "Please, they are killing me," he cried. Sixteen crewmen eventually gave up. Each was asked his name, then bound and blindfolded. "We had a copy of the ship's manifest," said Ariffin, "we knew one was missing."

Meanwhile, the sea had picked up. Ariffin tied the speedboat to the tanker's railing and scrambled aboard to find the engine room. It was there, an hour later, that he got a frantic call from Lukman on the bridge. The missing crewman had escaped in their speedboat, stranding them on the tanker. Ariffin ran the *Nepline Delima*'s engines at full throttle trying to reach international waters, but even at top speed the tanker could make only about 12 miles an hour. Within a few hours the Malaysian marine police had cut off their escape. Ariffin went up on the deck and lit a cigarette. "There was nothing to do," he said. "Allah had his hand on that sailor."

A guard signals that our time is up. I hurriedly tell Ariffin about my plans to visit Batam. The guard puts his hand on Ariffin's shoulder. The prisoner squeezes the phone. For the first time, I notice his muscular forearms. He speaks quickly before the guard leads him away.

"He said go to the coffee shop behind the Harmoni Hotel," says the interpreter. "Tell the seamen there that John Palembang said hello. And don't forget about the toothbrush."

CINDERELLA'S DARK SISTER "You want girls?" the cab driver asked on our way to Nagoya, one of Batam Island's largest towns. "Drugs?" he caught my eye in the rearview mirror. "I can get for you. Everything. No problem."

If Singapore, just seven miles to the north with its glittering skyline and robust economy, is Southeast Asia's Cinderella, Batam is her dark sister. The two are located across from each other where the Malacca Strait feeds into the smaller Singapore Strait, and a ceaseless parade of ships, more than a thousand a week, passes between them. Most do business in Singapore, home to one of the world's preeminent free ports and expanding financial and technology sectors.

In the 1980s Indonesia tried to mimic Singapore's success and began to transform Batam, one of the Riau islands off Sumatra's eastern coast, from a malaria-ridden fishing outpost into a tariff-free zone for entrepreneurs. Developers carved golf courses out of jungles and built casinos to lure tourists from Malaysia and Singapore. Investors backed factories and strip malls, office parks and apartment blocks. Indonesians flocked to boomtown Batam to find work. The island became a hub for maritime brokers, who hired sailors for shipping companies.

Batam, however, lacked Singapore's strict rule of law. Patronage and corruption took hold, and the island quickly became a haven for an exotic assortment of gangsters, smugglers, prostitutes,

and pirates. Illegally harvested timber, embezzled diesel fuel, stolen cars, drugs, weapons, and poached animals moved through its ports. Droves of Singaporean men ferried over on weekends to visit the growing number of brothels filled with impoverished girls. Meanwhile, some of the maritime brokers quietly engaged in their own side business: recruiting pirates for Asian crime syndicates. In 1997 the boom went bust when the Asian financial crisis hit. The investment money evaporated from Batam, leaving the island littered with abandoned construction sites. Unemployment rose, driving more people to the black economy. Though in the past couple of years investors had begun returning, the island still harbored a large class of residents who could only be described as desperate.

I asked the cab driver about the coffee shop behind the Harmoni Hotel. It's in Jodoh, he said, referring to Nagoya's seediest precinct. "Many murders there. Better you call me and I bring girls to you."

PHANTOM SWIFTLETS The first sounds one hears during a morning walk through Jodoh's narrow avenues are the whistles of swiftlets. Even the vendors hawking fruit, secondhand clothing, and used appliances smuggled from Singapore can't compete with the ebullient birdsong. It is one of Jodoh's many deceptions: the mating calls are taped and broadcast over loudspeakers to attract real swiftlets to build nests in the empty top floors of numerous buildings. The nests are harvested and each sold for hundreds of dollars to restaurants for bird's nest soup.

Another deception is the "coffee shop," a euphemism for the gambling dens where seamen meet brokers, trade gossip, drink beer, and bet a numbers game. However, in the year since Johan Ariffin, née John Palembang, has been in prison, much had changed in Batam. Most notably, Indonesia's new police chief has cracked down on gambling on the island, much to the detriment of the tourist trade, which relied on the stream of Singaporeans who filled Batam's resorts. When I arrived at the coffee shop behind the Harmoni, its windows were blacked and the front door was chained. This might have dimmed my hopes for finding John Palembang's friends had it not been for Jhonny Batam. I'd been given his name—one of his names—by someone he trusted. He was described as a gentleman of opportunity. A ship captain by trade, he had piloted vessels for both legitimate companies and less scrupulous entities. He was said to know every ship in port and every coffee shop deal in Batam. If anyone knew John Palembang, it would be Jhonny Batam.

> "We cast a spell to make the crew stay asleep. We can be invisible, bulletproof. It's a power that you learn."
>
> —*"Beach Boy," convicted pirate*

At first, contacting him was like chasing one of Jodoh's phantom swiftlets. Calls to his cell phone went unanswered until finally one morning he phoned to say he was stranded on Bangka Island, south of the Malacca Strait. Some "business" had gone badly, and he was broke. I agreed to wire him $80 for a plane ticket back to Batam.

As agreed, Jhonny Batam appeared the next day on a backstreet near a row of butcher shops. Animal blood ran in the gutters beneath the stifling odors of fresh meat. Jhonny, a handsome, bearish man in his 50s, wore an immaculate white sports shirt and pressed slacks, his wavy black hair perfectly coiffed. A fake gold Rolex dangled around his wrist, and he might have passed as a golf pro if not for the tattoos inscribed on his knuckles.

In a nearby restaurant, he said he knew John Palembang, whom he called a low-level seaman. The coffee shop grapevine had laughed at news of the *Nepline Delima* fiasco. "Amateurs," Jhonny scoffed. He began to describe his own career, how he had piloted tugboats and a ferry before taking the helm of a small cargo vessel. In time, he built a network of friends among sailors and harbor workers. Along the way he took side jobs, smuggling untaxed garlic, cigarettes, electronics,

and drugs. In the 1980s, he relocated to Hong Kong to work for Chinese crime syndicates. There his repertoire broadened to include making large cargoes "disappear."

He estimated that 75 percent of heisted cargoes were inside jobs involving the ship's crew, often the captain. "That's why most are not reported," he said, explaining that shipping companies often write off these losses rather than suffer bad press and risk losing their insurance.

It works like this, he said. A ship broker would call him and say there's a customer who needs diesel fuel. "I know a crewman on a tanker," Jhonny says. "I call his hand phone and ask him if he is happy. If he says yes, no problem. But if he says no, I tell him I make him happy, and then we make a plan." But the crewman won't work legitimately again, I said. He laughed. "Seamen have lots of names. Some have three or four passports. No problem."

Over two weeks, I interviewed several of Jhonny's former crewmen spread among the Riau Archipelago and a captain who knew him in Hong Kong. All corroborated what Jhonny told me. One sailor said he trusted Jhonny because "he never lies. He always pays what he says he will pay. Sometimes the legal ships don't do that."

In my hotel room, we laid a map of the Malacca Strait on the bed. Jhonny's thick fingers traced the coastlines with practiced familiarity. He pointed to places with obscured shoals and noted currents and unmapped islands. "This area," he drew his finger around Batam and Singapore, "too many patrols now." He moved his finger to a spot south of the strait, "now the best place for shopping is here."

"Shopping," Batam argot for the lowest level of piracy, is roughly equivalent to robbing a liquor store. Even the smallest cargo ships and tankers carry sizable amounts of cash, used to buy supplies in port and to pay the crew. Often these ships are older and have less security than newer, larger ships. Sometimes, Jhonny says, the captains are running their own scams, conserving fuel by going slow, then selling the excess to passing ships and pocketing the cash. He explained that shopping trips are carried out by teams of "jumping squirrels," pirates who use wooden boats called *pancungs*, rigged with powerful engines, to stalk the ships at night and climb up the sides and rob the crew. I tell him I would like to meet a jumping squirrel. "It's possible," he said, and dialed a number.

BULLETPROOF JUMPING SQUIRRELS It was dark when a slender young man with bleached highlights in his short dark hair and a small silver hoop in his left ear knocked on the door. He looked stunned to be greeted by a foreigner and grinned nervously at Jhonny, his smile marked by the black, ragged edge of a rotted front tooth. "Is this dangerous?" he asked.

Jhonny introduced him as Beach Boy. With his bronze skin, athletic physique, and large waterproof watch, he looked the part. Just ten months out of an Indonesian prison, Beach Boy had served two years for his role in hijacking a barge carrying more than a million dollars' worth of crude palm oil. After making off with the cargo, his gang scattered. But Beach Boy's accomplices betrayed him to the police. Once in custody, he says he was interrogated, beaten, and shot in the leg. He rolled up his left pant leg to reveal a fist-size scar on his calf. "The bullet is still in there," he said. Yet the most painful consequence of his prison term, he said, was the loss of his family. His wife wrote him in prison that she had left him for another man.

I asked Beach Boy why he had become a pirate. "I can't get work," he said. Jhonny explained that Indonesian sailors often lacked the maritime certifications required to work on commercial ships. For years, young men like Beach Boy relied on older seamen to teach them the trade and then obtained counterfeit credentials to avoid the expensive training needed to become legally licensed seamen. But in recent years the international shipping community had clamped down on such practices, leaving many experienced Batam sailors unemployed.

I pressed him on how his team was able to board ships undetected. "We use magic," he said. "We cast a spell to make the crew stay asleep. We can be invisible, bulletproof." He pointed to his head. "It's a power that you learn." Then how did you get shot, I asked. "They fired twice," he said. "I resisted the first bullet but wasn't strong enough for the second." *(Continued on page 146)*





A family performs evening chores at its house floating on the Musi River, which bisects Palembang. For centuries the Sumatran city thrived on booty raided from ships in the strait and brought upriver. Now it's a transport hub for the island's oil industry.





A Muslim family in the fishing village of Sungsang bathes the body of five-year-old Karmila, who died during the night. Her father, Anwar, blames malaria, a killer in Sumatra's impoverished coastal villages, which reap little of the vast wealth that passes through the strait.





Burning incense hails the Chinese New Year at a Taoist temple in Malacca, a 16th-century port so strategic to trade that its ruler was said to have “his hand on the throat of Venice.” Its anchorage is now a footnote, but its name still conjures visions of wealth and pirates.

Later that night at an outdoor café, Jhonny and I loitered over a few beers, and he revealed that he believed in mathematics, not magic. He borrowed a pen and on a napkin demonstrated how he could reduce my telephone number, or any seven-digit figure, to the number eight using a series of equations. "It looks like magic," he said. "But it is mathematics." Numbers, he said, always had fascinated him. As a boy he'd memorized several of these numeric parlor tricks and later taught himself algebra and geometry. At sea he'd come to trust numbers far more than superstitions. They told him how far he traveled, when to turn, how much fuel his ship needed, how hard the wind blew. Numbers were predictable, accountable, reliable—qualities that were hard to come by in Jhonny's world.

He continued to doodle on the napkin and asked if I'd heard of the golden mean, which he described as a ratio discovered by Greek mathematicians that represents perfect balance. Riau seamen had their own golden mean, he said, which measured the tipping point between working within the bounds of the law versus working illegally. As long as this Malaccan version of the golden mean favored robbing ships, there would be pirates in the strait.

PIRATE TRAINING A few days later, Jhonny, Beach Boy, and I caught a cab to the port. Beach Boy had arranged to show me how a team of jumping squirrels boarded a ship. He said there was an uninhabited island not far from Batam where he occasionally trained.

At the end of a sun-bleached jetty, two muscular young men, "Muhammad" and "Hakim," waited for us in a wooden pancung. Beach Boy explained that these boats were ideal because their weight and shape let them cut through a ship's wake, unlike fiberglass boats, which were much lighter and would bounce in rough water.

We sat in the boat, two by two, and I ended up next to Muhammad. His round cheeks and perfect teeth gave him a boyish appearance, but weeks before he had completed a two-year prison term for his role in a shopping trip. "Are you ready to learn how to steal a ship?" he asked.

With the sun beating on our shoulders, Hakim steered out of the harbor and made for a dense forest that appeared to be floating on top of the water, one of the strait's innumerable mangrove islands. It seemed an impenetrable mass of gnarled roots and tangled limbs, but Hakim found a little cut and piloted the boat into the labyrinth. It was cool inside the mangroves, and we slipped in and out of deep shadows following the watery path until it opened on a cloister of stilt houses. *"Assalamu alaikum,"* Hakim called out. No answer. He cut the engine. Beach Boy grabbed a limb and held the boat steady as Hakim drew a parang, its curved blade glistening with oil used to keep it razor sharp. With quick, latent blows Hakim chopped out a two-foot section of a root and tossed it into the pancung.

> "A few years ago this was a favorite place to begin an attack. Now there are too many patrols, but there are other places."
>
> —*"Muhammad," convicted pirate*

We navigated out of the mangroves and headed for a small island about a mile away. Once ashore, Beach Boy disappeared into its dense jungle. The rest of us remained on the beach, which had a broad view of the shipping channel. Nine vessels chugged through the strait, including a liquefied natural gas tanker that towered over the others like a skyscraper. The Singapore skyline loomed beyond. "A few years ago this was a favorite place to begin an attack. Now there are too many patrols," said Muhammad, flashing his perfect teeth, "but there are other places." I asked him why he'd gotten into piracy. "Partly for the money," he said, "but it is fun, an adventure, like James Bond."

Beach Boy emerged from the jungle with a 20-foot-long bamboo stalk. He stripped the shoots off the bamboo, while Hakim used the parang to hew the mangrove root into a footlong spike. When they finished, Hakim lashed the spike at an angle to the end of the bamboo. "This is how we

climb onto the ship," Beach Boy said, motioning to a nearby tree as if it were the side of a ship. "The *tekong* [driver] maneuvers the pancung right up to the stern," he said, lifting the pole and hooking the spike onto an upper branch.

In one fluid motion he grabbed the pole with both hands and pulled himself upward, lifting his legs, then clasping the bamboo with his feet and driving his body upward inchworm fashion. In seconds he reached the top and then slid down the pole. "This is how five jumping squirrels can all board a ship in less than a minute." He handed me the pole. "Now you try."

I kicked off my shoes and copied the technique. The bamboo's natural joints offered a good grip, even when wet, and its stiffness made it easier to climb than a rope. To reach the decks of taller ships, Beach Boy said they would lash two or three bamboos together. I reached the top and slid down. "You could be a pirate," Muhammad said. The others laughed. I started to put on my shoes when I felt a powerful grip on my shoulder and a cold blade of a parang on the back of my neck. "Then you grab the first sailor you see," Muhammad barked in my ear, "tell me where the money is." My heart skipped a beat before I realized he was just demonstrating the next step in an attack. "And the sailor will follow you like a water buffalo."

Back in the pancung, we headed for Batam, but as we approached the harbor, Hakim veered toward one of the hulking cargo ships anchored just outside. Crewmen were hanging wash on the railing. Beach Boy waved, and the sailors lazily waved back. Hakim maneuvered the pancung to the ship's stern and drew up beside the rudder. "This is the hole," Muhammad said, his voice echoing off the steel hull. "The crew can't see us here." I looked up and saw that the curving hull shielded the pancung from the deck. "When the ship is moving, the water is very rough here." He pointed to a spot on the surface over the ship's massive propeller. "The tekong has to hold the pancung steady while we raise the bamboo and climb up. That's why the tekong always gets the biggest share of the money."

"But you have to board the ship, subdue the crew, find the money, and not get killed," I said. "That's easy," he said. "Are you ready to try?"

HAPPY HAPPY Back in Batam, Jhonny and Beach Boy offered to show me where pirates would go to get "happy happy." Jhonny and others told me that after major heists pirates would often jet off to luxury hotels in Jakarta and blow big wads of cash on unimaginable indulgences, including a strip club where you could eat sushi off the bellies of the dancers. But after a shopping trip, Batam pirates might celebrate at one of the local karaoke bars. "We will go to Die Nasty," said Jhonny. Beach Boy nodded.

Late that night, the three of us walked through Jodoh's dark streets, where beckoning young women in low-cut blouses vamped under lighted signs advertising karaoke. We arrived at our destination, which turned out to be a club called Dynasty. The dank room smelled of clove cigarettes and was dimly lit with orange bulbs that cast a lurid glow. A waitress escorted us to a table and brought over beers. Beach Boy scanned the menu of songs that customers could request to sing. Along the far wall, a row of young women sat beneath a line of spotlights. Each wore a round badge with a number. They giggled coquettishly, competing to make eye contact with us. "Karaoke hostesses," Jhonny explained. He went over to the women and made his way down the line, smiling and chatting. Finally he returned with a young woman who settled between Jhonny and me.

"What your name?" the woman asked in heavily accented English, patting my thigh. I told her and mentioned that I was here just for the karaoke. "Yes," she said, "everyone come to Die Nasty for karaoke."

Beach Boy selected his songs, and the waitress came over with the microphone. The music began and the lyrics to Led Zeppelin's "Stairway to Heaven" were projected onto a large screen. "There's a lady who's sure all that glitters is gold, and she's buying a stairway to heaven." Sitting in the dark, holding the microphone close to his mouth, Beach Boy seemed transformed. He closed his eyes and crooned in a pleasing tenor. "Ooh, it makes me wonder."

The girl next to me leaned close. I could smell her perfume mingled with the alcohol on her breath. "Please can you help me? I am ugliest girl at Die Nasty. I have no customer in two



GILDED CITY A tour boat cruises by Singapore's financial district. In four decades the city-state has risen from sleepy entrepôt to economic powerhouse. To those who prey on ships, its skyline offers a glittering reminder of the riches that flow through the nearby sea-lanes.

week." She said she had to pay the owner of the club each month for room and board and to reimburse the cost of her travel to Batam from her village in eastern Java. I slipped her a little cash.

Jhonny finally took the microphone. By this time there were a few empty bottles in front of him, and his mood was effervescent, joking with the karaoke hostesses, teasing the waitress, buying drinks. He sang an old Rod Stewart song, "Sailing," but halfway through I noticed he wasn't following the English lyrics. He seemed to be singing in Indonesian and making up the words as he went. Everyone was laughing until the chorus came back, and he returned to the lyrics on the screen. He waved his arms, motioning us all to join in, and soon everyone at the Die Nasty was in Jhonny Batam's thrall.

THE 17TH CREWMAN One sailor who was never charmed by a pirate was Mohamed Hamid. He was the crewman who escaped from the *Nepline Delima* and led the police back to rescue the crew. I went to visit him at his home in Malaysia, far from the Malacca Strait. The experience had pushed him to abandon a promising career as a sailor at age 28. He asked me not to reveal his village because he fears retribution.

We sat on mats on the porch of his father's stilt house, and he recounted what he called the most frightening night of his life. He heard the



captain's pleas over the loudspeakers and was on his way to the bridge to surrender when one of the pirates suddenly put a knife to his throat. "I thought this is my death," he said, but instinct took over and he hit the pirate with an elbow, jumped down three flights of stairs, and scurried under some pipes on the main deck. He lay there reciting Muslim prayers, trying to compose himself, when he saw the rope tied to the railing leading to the pirates' speedboat.

He described his escape as almost comical. He caught his foot on the railing and fell into the speedboat. Then it took several agonizing minutes to cut the thick rope with a dull pocketknife. Afterward he lay sweating in the bottom of the boat as it drifted from the tanker into total darkness. Feeling his way to the stern, he traced the wires from the motor to the ignition switch. Clouds obscured the stars that would have guided him to land; rain began to fall. In the distance he could still hear the cries of his captain over the tanker's loudspeakers as the pirates beat him. "I prayed to Allah, 'You brought me this far, please show me the way.'" He cranked the engine and hoped he was headed toward help.

Less than 24 hours later, Hamid was hailed as a hero. He had reached the Malaysian island of Langkawi and had been able to guide the marine police back to the *Nepline Delima.* After a tense standoff, all ten pirates surrendered.

Eventually nine of them received jail sentences. One pleaded not guilty and is still awaiting trial. The shipping executive and the alleged conspirator on the *Nepline Delima* were arrested. Both say they are innocent. Their trials are pending. Hamid was stunned to learn of the charges against his fellow crewman. "It was like finding out the devil is your brother."

TWO MONTHS LATER I was back in the U.S. at a wedding reception when my phone vibrated with a text message from Jhonny Batam: "Got job as master on motor tanker . . . Jhon." Guests were climbing on stage to sing with the band, and for a moment I was back at the Die Nasty watching Jhonny and Beach Boy sing karaoke. No pirate attacks had been reported in the Malacca Strait since I left. Indonesia and Malaysia had called on foreign governments to help fund their patrols. Without more resources, it is unclear how long the cash-strapped Indonesian navy will maintain its current level of vigilance.

As for the fate of this tanker, maybe, I told myself, Jhonny had embarked on a new path, thankful for legal work, loyally serving his new employer. But if there were more money to be made working another angle, I could hear him say, one must be true to the pirate's golden mean. After all, Jhonny Batam is a gentleman of opportunity. □

Pirate Tales "How much should you trust what a pirate tells you?" wonders author Peter Gwin. See his Field Notes and more at **ngm.com/0710.**

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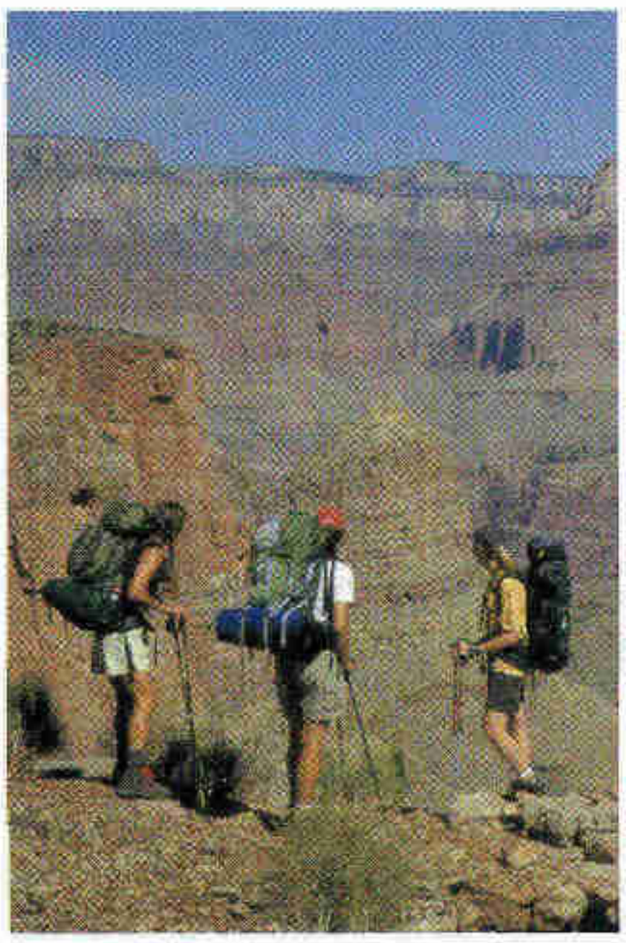
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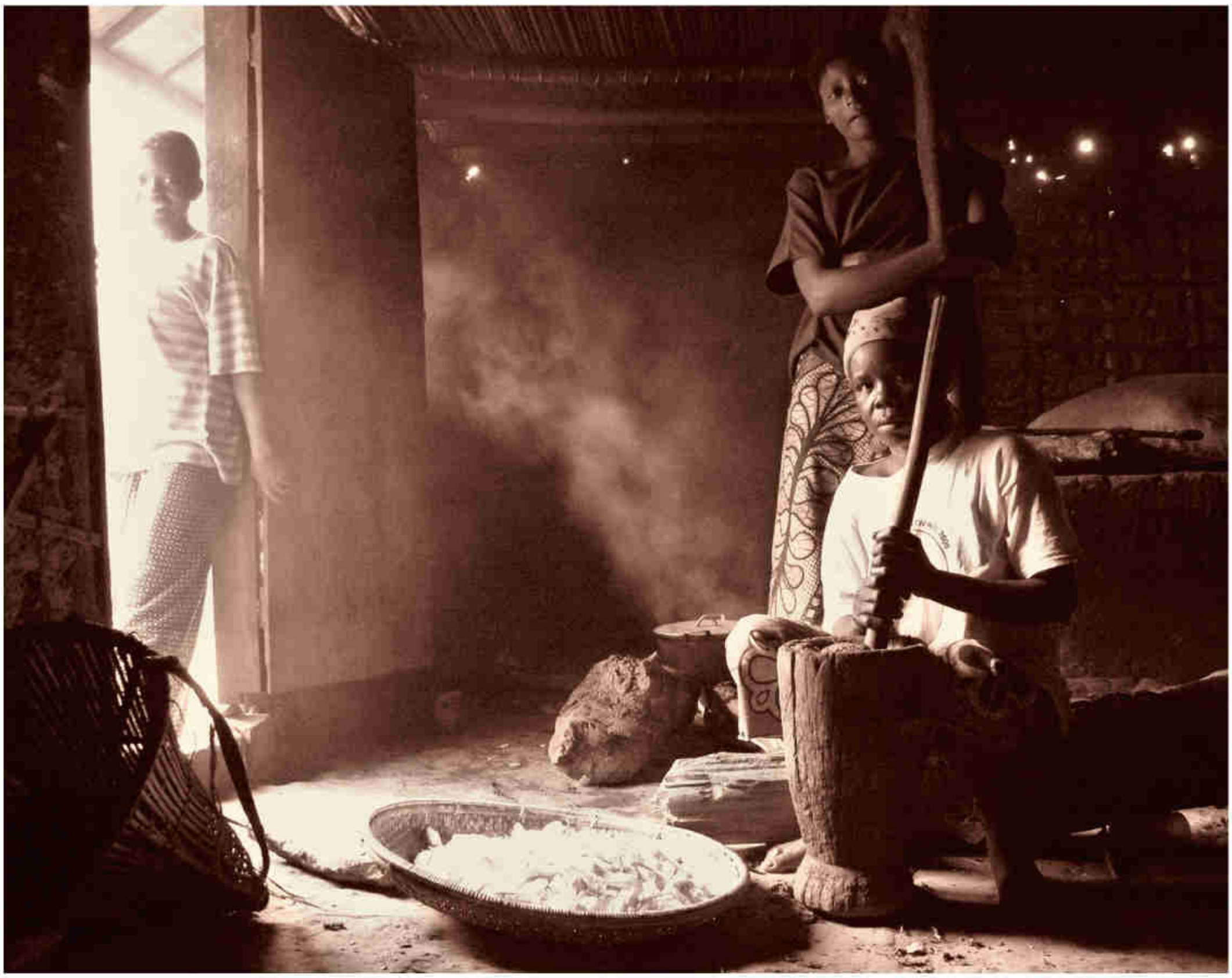
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HOW TO HELP



Congolese nuns (above) help villagers of Vango by pounding grain by hand. The women trek three miles to a river for water.

ZOONOTICS, PAGE 78 **For Vango** "It's hard to imagine how remote the Democratic Republic of the Congo is," says Anne Rimoin, a professor of epidemiology at UCLA and a pioneer in monkeypox research. To combat zoonotic diseases like monkeypox, Rimoin has spent many months in the central Lomela region. In a nation about a quarter the size of the U.S., there are few miles of paved roads, "and not a single one where I work," says Rimoin.

There also isn't much of a social support network. One of her research sites is Vango, a village that relies on its parish nuns and priests for schooling and basic medical care. Rimoin relies on them as well to gather data about health issues. But these Good Samaritans need help. From 1998 to 2002, Rwandan soldiers overran Vango. Most villagers fled to the forest. The soldiers tainted the parish's well, burned its truck, and stole anything they could, including the convent roof. Support doesn't easily reach such distant spots, so Rimoin set up a nonprofit, Congo BioMed, to promote local biomedical research and training, and to deliver aid. Contributions to Congo BioMed may be sent in care of Anne Rimoin at UCLA School of Public Health, 650 Charles E. Young Drive South, CHS 71-279B, Box 177220, Los Angeles, California 90095-1772.

PHOTO: LYNN JOHNSON

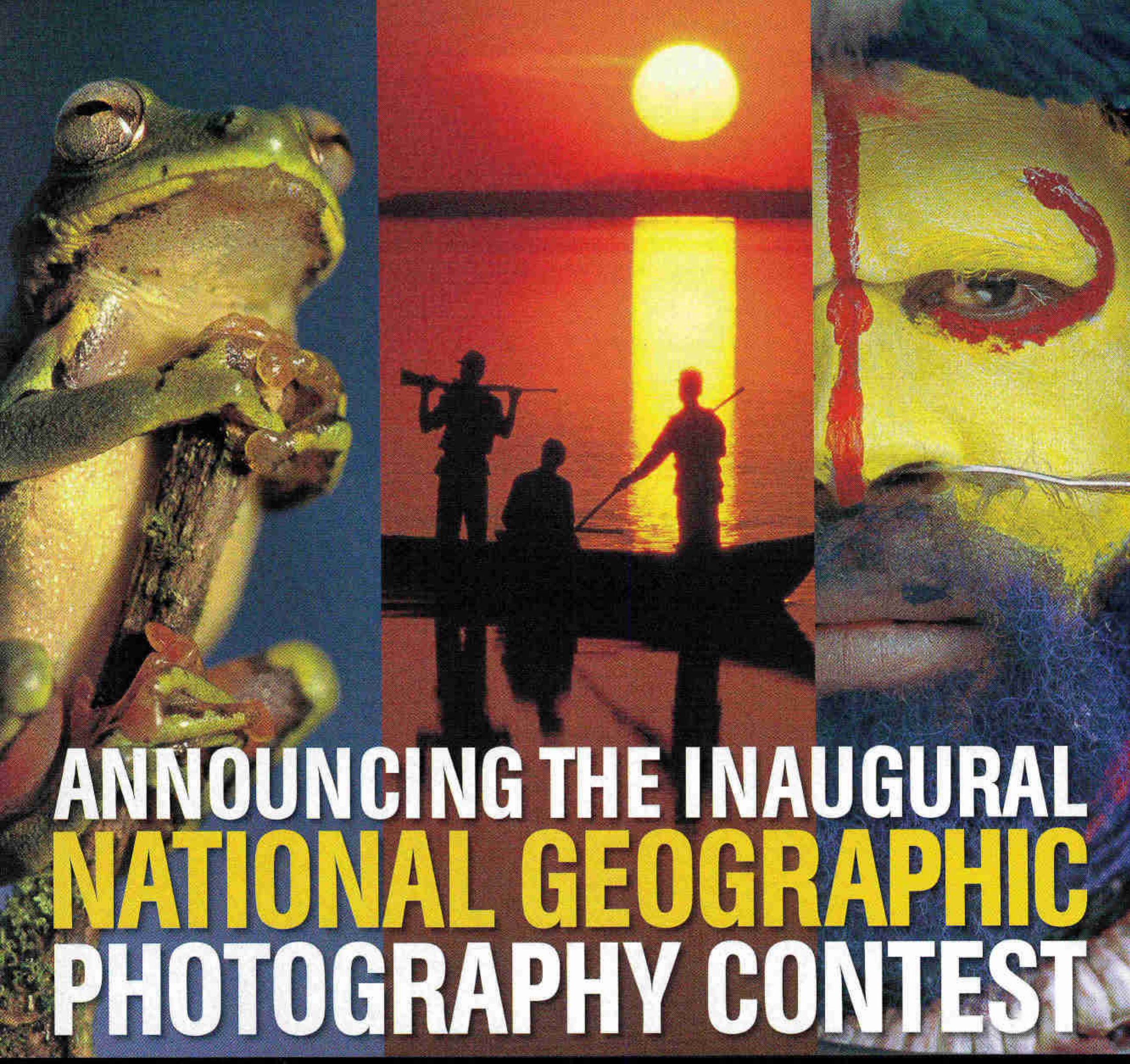
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THERE AT EVERY TURN.



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PHOTOS:
MICHAEL NICHOLS (LEFT, CENTER), JODI COBB (RIGHT)

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Members of the International League of Conservation Photographers make images that inspire awe—and change.

These ILCP members have contributed to NATIONAL GEOGRAPHIC:

James Balog
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David Doubilet
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Frans Lanting
Michael Nichols
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Klaus Nigge
Norbert Rosing
Joel Sartore
Brian Skerry
Steve Winter
Christian Ziegler

More Than Pretty Pictures

"If you Googled 'conservation photography' in mid-2005, you got how to archive pictures in museums," says Cristina Mittermeier. Now, the first entry is the International League of Conservation Photographers (ILCP), the environmental group she and 34 others founded two years ago at the Eighth World Wilderness Congress in Anchorage, Alaska. Today the ILCP boasts 64 members, including 46 fellows who organize the group's Rapid Assessment Visual Expeditions (RAVE) —quick visual surveys of the world's most endangered regions. Last spring the first RAVE, in Mexico's El Triunfo Biosphere Reserve, yielded 35,000 images and 19 hours of film in less than three weeks.

"Conservation photography is born out of purpose," Mittermeier says. "Anyone can purchase equipment and learn the secrets of wildlife behavior. What can't be purchased is the empathy necessary to create awe-inspiring images that move people to act."

Empathy for the oceans earned full membership status in the ILCP this year for photographer Brian Skerry (see "Global Fish Crisis" in the April 2007 GEOGRAPHIC). "I've been diving and photographing for 30 years, but I often felt like I was preaching to the choir," he says. "ILCP gets my message out to legislators —and the average Joe buying fish in the supermarket."

Learn more about the photographers and their projects at **ilcp.com.**

PHOTOS (CLOCKWISE FROM TOP LEFT): MICHAEL NICHOLS, NG IMAGE COLLECTION; CHRISTIAN ZIEGLER; JOEL SARTORE, NG IMAGE COLLECTION; BRIAN SKERRY, NG IMAGE COLLECTION

SPECIAL RESEARCH REPORT

30 DAY RISK FREE TRIAL

Effects of stress reversed by amazing new medical device.



Now you can enjoy the pleasures of stress-free living and feel younger in just 15 minutes a day. It's surprisingly easy with the remarkable new medical device called the StressEraser.

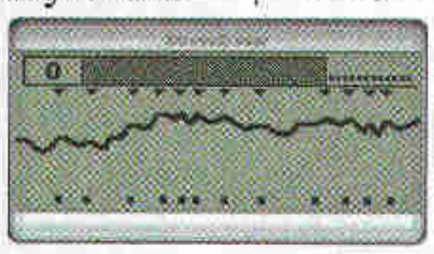
This medical breakthrough actually reverses ergotropic tuning; the harmful process that causes your nerves to respond faster and more strongly to stress; making you feel it more easily, more quickly, more intensely.

Medical Discovery Leads to Breakthrough in Reducing Stress.

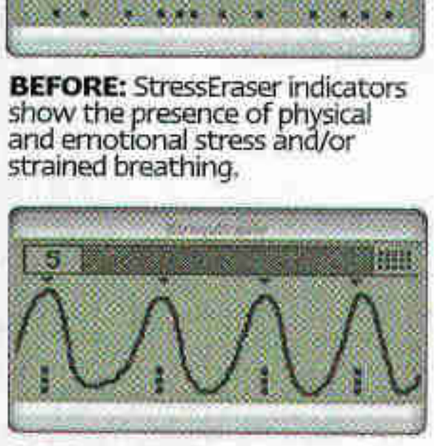
Medical researchers now know that the harmful effects of ergotropic tuning are intricately connected to the biological mechanisms of breathing. More importantly, they learned that you can actually regulate the stress-producing activity of this system by regulating this basic bodily function.



To do this, Helicor, Inc. has developed the amazing StressEraser that measures the effects of breathing and guides the user to control this basic biological activity.



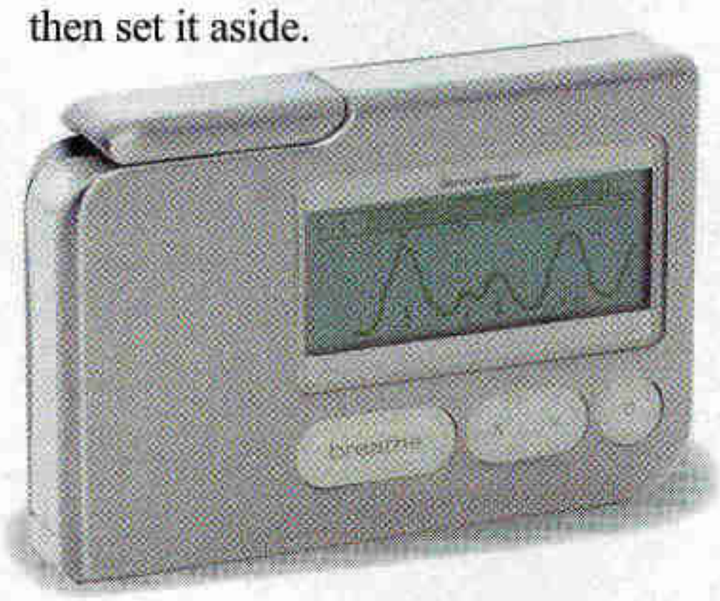
BEFORE: StressEraser indicators show the presence of physical and emotional stress and/or strained breathing.



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Compact and easy to use – takes just 15 minutes a day.

The StressEraser is designed to fit in the palm of your hand and is simple to operate. All it takes is a relaxing 15 minutes right before bed each night to adjust your breathing; then set it aside.



Your system will continue to reverse the effects of the stress you've built up all day – while you sleep!

Erase stress while you sleep and feel good again in 30 Days.*

Within two weeks you will begin to feel a difference all day long. And within a month, you will feel like you did when you were young, before the stresses caused by ergotropic tuning, became part of your life.

The StressEraser Guarantee:

Try the StressEraser before bed FREE for 30 nights and Helicor guarantees you will feel good again or simply return it. No questions asked.

"The StressEraser is a ground-breaking achievement in the area of stress reduction and biofeedback."

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MSNBC

"Now you don't have to use a $3000 machine at your doctor's."

Forbes

"You feel so relaxed yet focused."

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"9 out of 10"

WIRED

"...my forehead, neck and shoulders felt more relaxed"

The Washington Post

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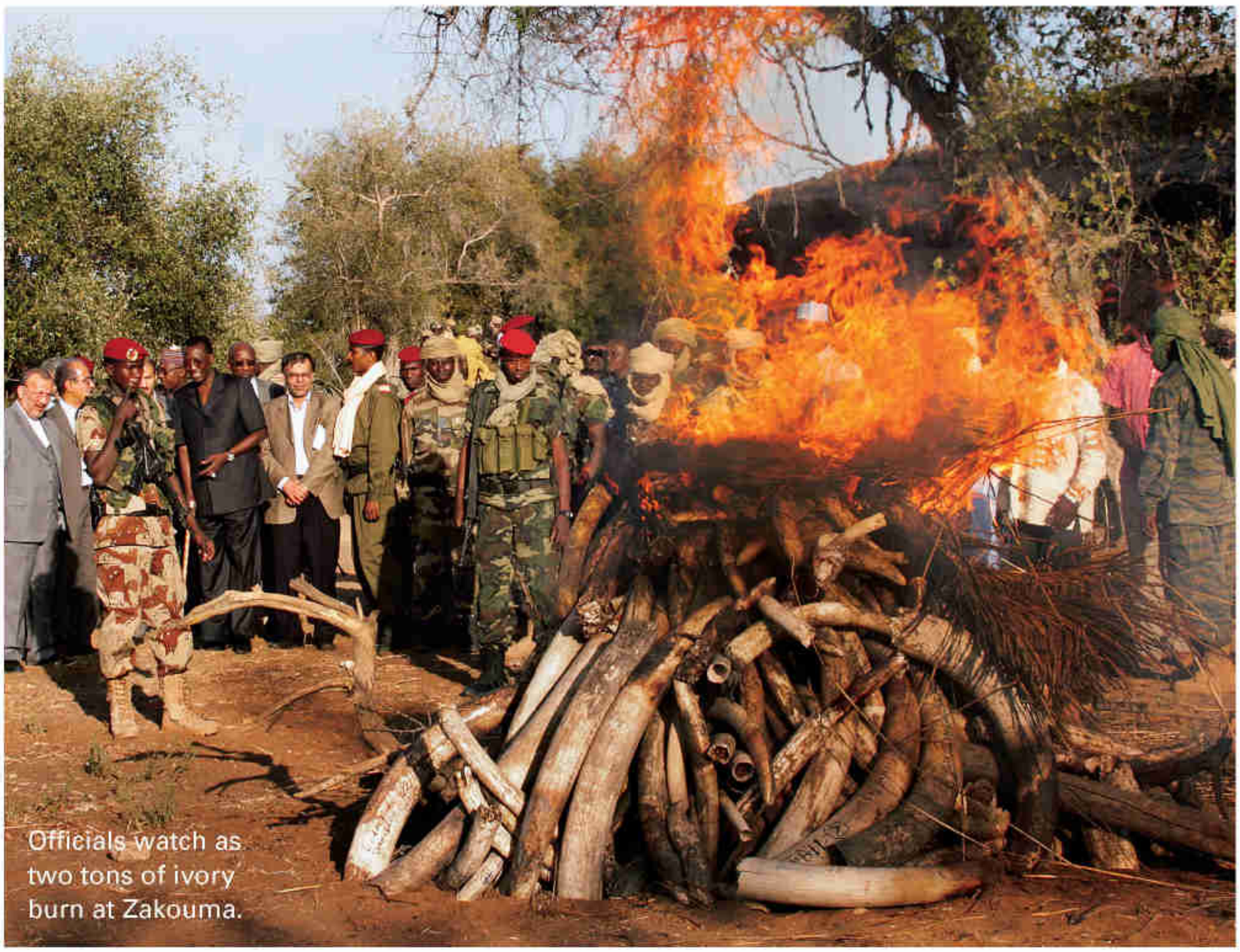
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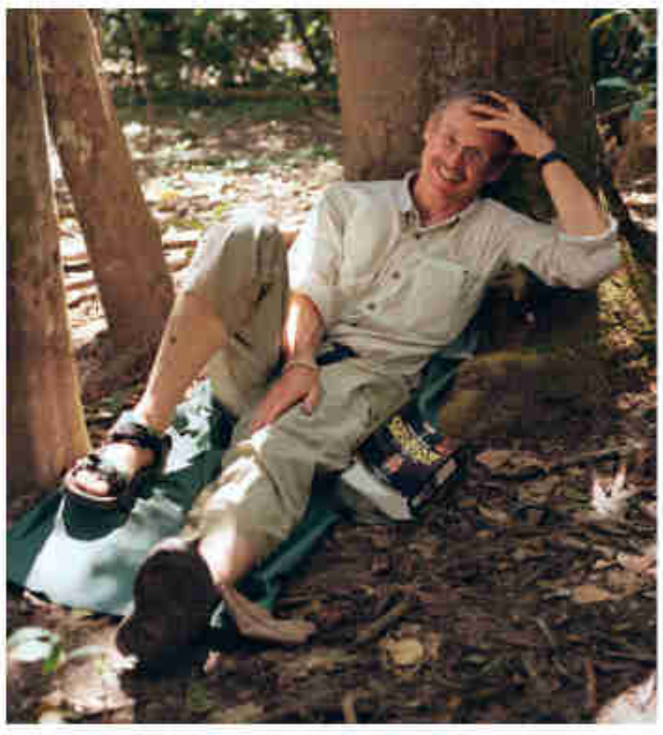
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LAD-00091-RevB



Officials watch as two tons of ivory burn at Zakouma.

UPDATE **Fired Up** Chad's President Idriss Déby takes a special interest in his country's Zakouma National Park. Recently, when park administrator Luis Arranz told the president he needed help to protect elephants from poachers, Déby assigned 80 more men to patrol the reserve. Visiting Zakouma in February, Déby (above, in black) observed the burning of confiscated tusks worth some $100,000. Destroying the ivory made a strong statement to poachers—and made sure it never would be sold. Since our March 2007 "Ivory Wars" story, GEOGRAPHIC readers have contributed more than $250,000 to help the park. For more information, see the Wildlife Conservation Society website *wcs.org/savingelephants.*



David Quammen waits under a tree.

ON ASSIGNMENT **Waiting for Gorillas** David Quammen was reminded of a central fact of field biology in a remote forested region of the Republic of the Congo: There's a lot of sitting around. Quammen, who wrote this month's story on zoonotic diseases, was in the field with a team that headed out every dawn to watch a clearing that once was popular with gorillas. Veterinarian Billy Karesh kept his air rifle and tranquilizer darts ready, but no gorillas showed up. "If you're sitting in the forest in one place waiting for something to happen—and it doesn't happen—eight days is a long time," Quammen says. The researchers, writer, and photographer waited through rain and sun and insects. Quammen took many naps, even while standing up during a downpour. Between showers, he read a biography of Theodore Roosevelt and told his teammates anecdotes about the President.

PHOTOS: NURIA ORTEGA (TOP); LYNN JOHNSON

If You Received an Unsolicited Call or Fax that You Believe Came from an Herbalife Distributor

You May Benefit From a Proposed Class Action Settlement

A Proposed Settlement has been reached in a class action against Herbalife International Inc. and some of its distributors. The case is *Mey v. Herbalife, et al.,* No. 01-C-263M, and it is pending in the Circuit Court of Ohio County, West Virginia.

What is the lawsuit about?

The lawsuit claims that Herbalife distributors initiated unsolicited calls or faxes to promote Herbalife products or business opportunities to persons who did not have a customer or busines relationship with Herbalife or its distributors, in a manner that violated federal telemarketing law. Herbalife and the distributors deny that they did anything wrong. Herbalife also denies that it is legally responsible for the acts or omissions of its independent contractor distributors.

Who can make a claim?

You may be a Class Member entitled to make a claim if you (a.) received an unsolicited call or fax from an Herbalife distributor (or from Herbalife or a company that provided leads to Herbalife distributors) from July 16, 1999 through July 2, 2007, and (b.) did not have a customer or business relationship with Herbalife. The call or fax did not have to mention Herbalife by name.

What are the terms of the Proposed Settlement?

The Herbalife distributors and Herbalife have agreed to create a $7 million Settlement Fund that will be distributed to Class Members. The amount you can get depends on the number of people that file a claim but it will not exceed $75. To make a claim, you must complete and send in a claim form certifying that you received a call or fax as described above.

Class Counsel will request fees of $2,331,000, plus actual costs, which, if approved, will be deducted from the Fund. Administrative Costs, Notice Costs and approved class representative compensation will also be deducted from the Fund.

What are my rights?

- **You can make a Claim** to get money from the Settlement Fund. All Claim forms must be postmarked no later than **November 13, 2007**.
- **If you do not want to be a member of the Class**, you must send a letter and ask to be excluded. Your request must be postmarked no later than **November 13, 2007**. If you do not exclude yourself, you agree never to sue Herbalife or its distributors in the future for the claims covered by the Proposed Settlement.
- **You can tell the Court if you do not like this Proposed Settlement** or some part of it if you do not exclude yourself. To object or comment, you must send a letter that is mailed and postmarked no later than **November 13, 2007**. You may also hire your own lawyer, at your own cost, to speak for you.

The detailed Notice, available below, explains how to exclude yourself or comment on the case. It also explains what rights you are giving up if you stay in the Class.

Will the Court approve the Proposed Settlement?

The Court will hold a Final Approval Hearing on **January 15, 2008 at 10:00 a.m.** to consider whether the Proposed Settlement is fair, reasonable, and adequate, the motions for attorneys' fees and expenses, and compensation for the Class Representatives. If comments or objections have been received, the Court will consider them at that time.

For a Detailed Notice and a Claim Form, Visit: www.tcpasettlement.com

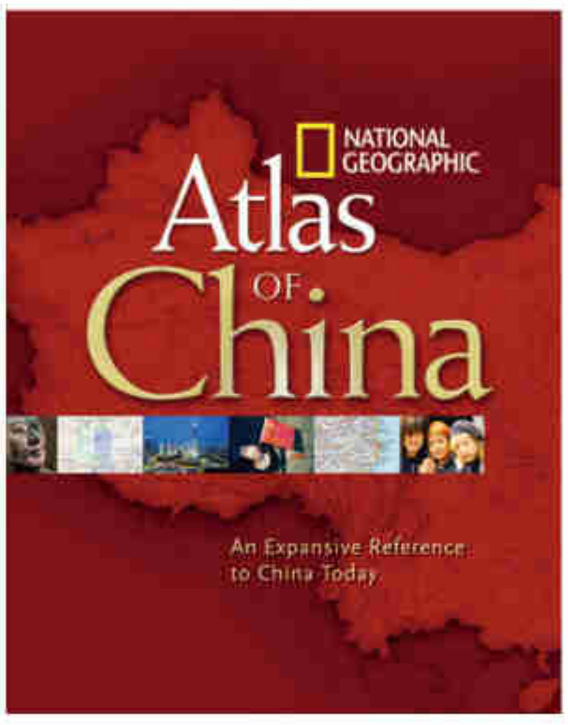
Or Write: Herbalife TCPA Class Action Settlement Administrator
c/o A.B. Data, Ltd., P.O. Box 170500, Milwaukee, WI 53217-8091



The *Styxosaurus* measured 35 feet from tail to tooth.

NG GIANT SCREEN FILMS See Monsters About 80 million years ago, much of the world we know today as dry land was covered by ocean. Now creatures that prowled these depths star in *Sea Monsters: A Prehistoric Adventure,* a new giant screen film. Finds from digs across the globe spring to life with photo-realistic computer animation of animals in action, including the long-necked *Styxosaurus* (above) and the massive *Tylosaurus*—so fearsome it even had teeth on the roof of its mouth. *Sea Monsters* premieres on IMAX, IMAX 3D, and other specialty screens this month.

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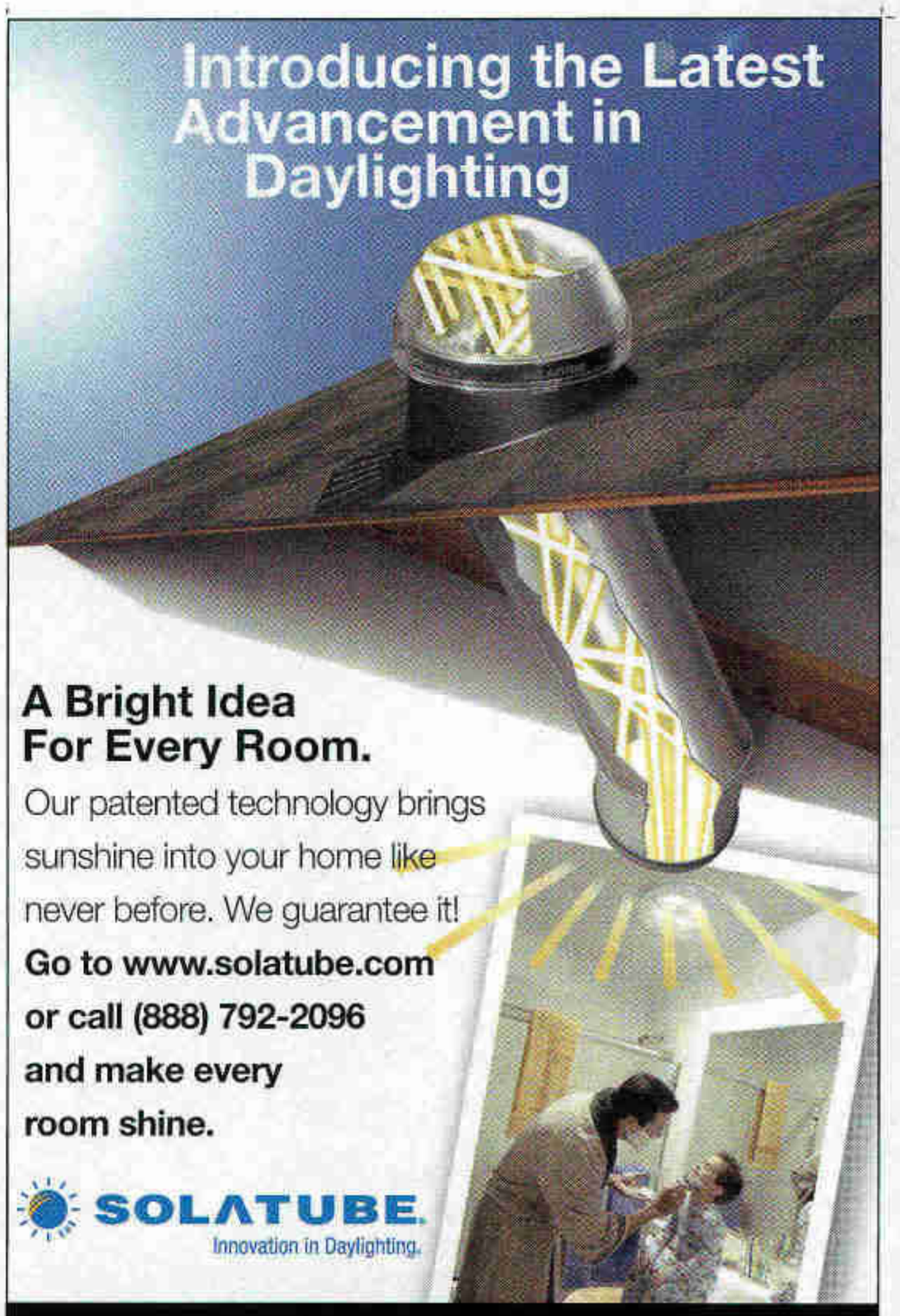


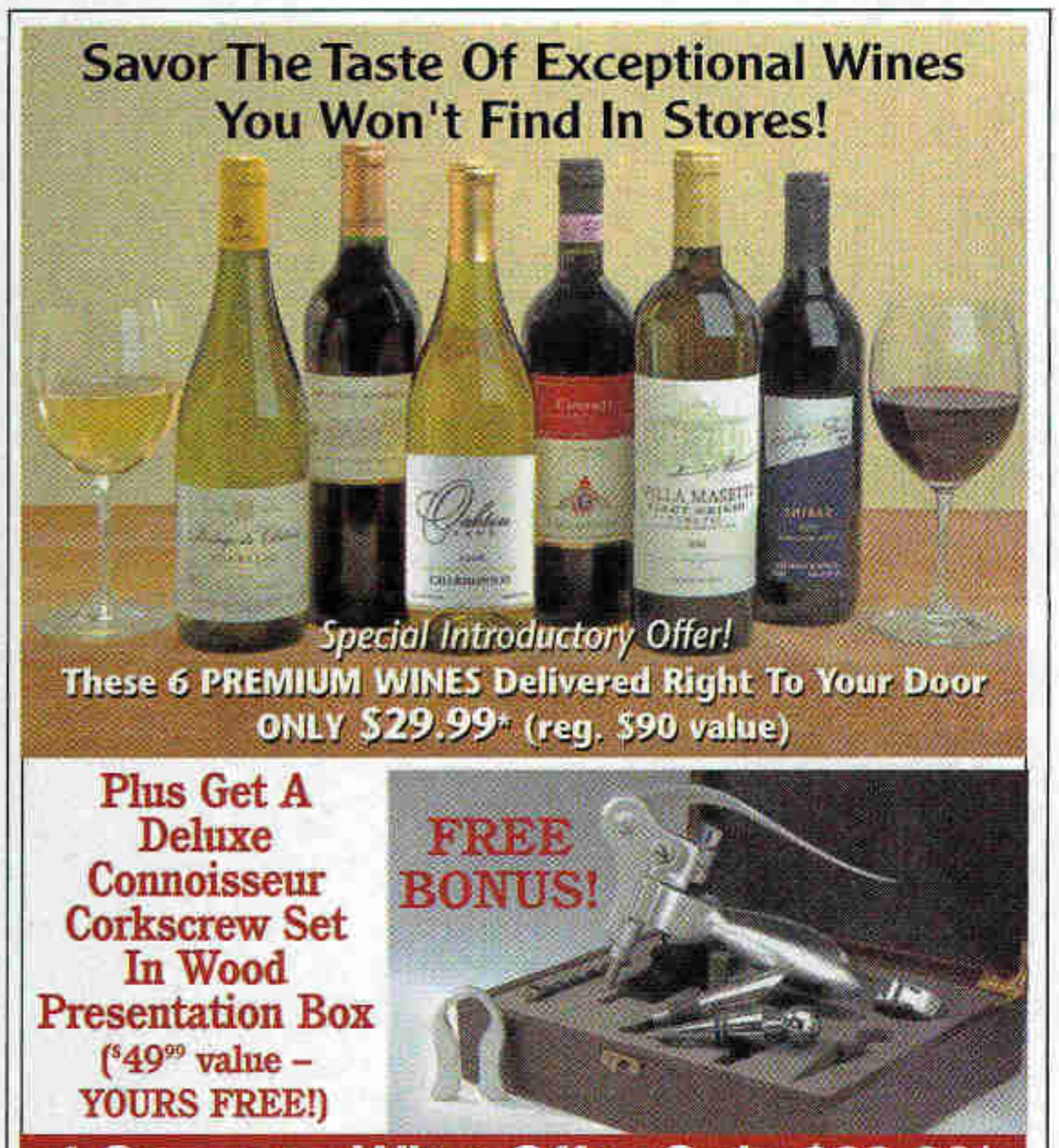
Atlas of China

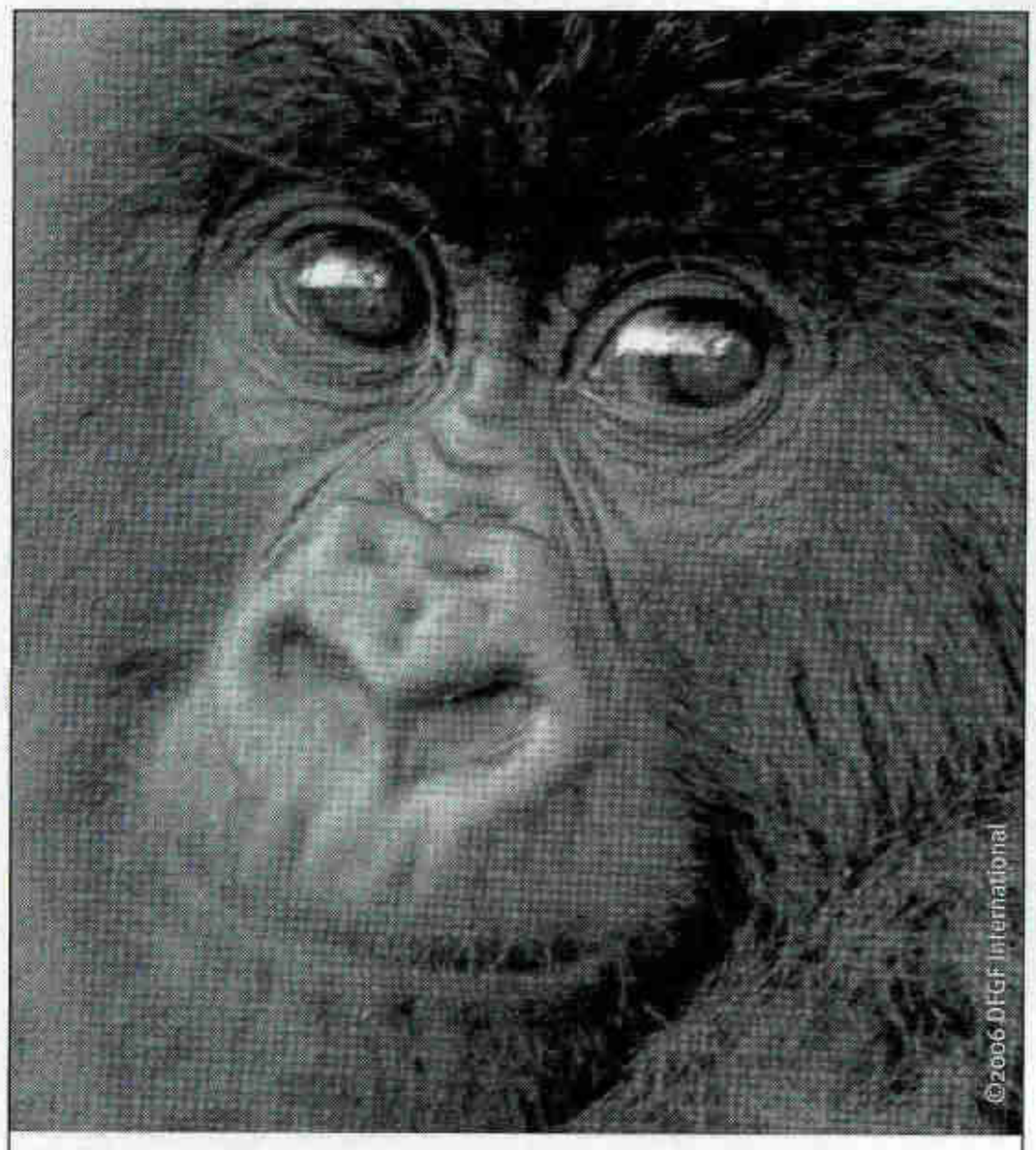
Get an overview of the world's most populous country—and a closer look as well—with National Geographic's new 128-page *Atlas of China*. With more than 400 full-color maps and illustrations, the atlas covers people, places, climate, and culture of China. Its annotated index, from a database in the making for nearly a year, has a level of detail unprecedented in an English-language atlas of China, referencing some 5,000 features (place-names, geographic features, transportation routes, and more) shown in the volume's sectional maps. A pronunciation guide is also included. "Unless you read Chinese," explains Carl Mehler, project editor for the atlas, "this kind of information was almost impossible to find in one place before. There really is no other publication like this."

The National Geographic *Atlas of China* is now available in bookstores everywhere ($26).

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FLASHBACK



The Primate Directive He weighed nearly 40 pounds—on Earth. But in January 1961, for six and a half minutes during a 16-minute flight aboard the Mercury-Redstone 2 rocket, Ham the chimpanzee was weightless. NASA scientists used the chimp's flight to study life-support systems for the human astronauts they'd soon send into space: Sensors monitored Ham's vital signs while computers tracked his execution of simple tasks. He passed all flying tests with flying colors. "A bruised nose," noted the May 1961 GEOGRAPHIC article where this photo of the chimp's return appeared, "was Ham's only injury." *—Margaret G. Zackowitz*

Flashback Archive Find all the photographs at **ngm.com.**

PHOTO: HENRY BURROUGHS, AP IMAGES

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